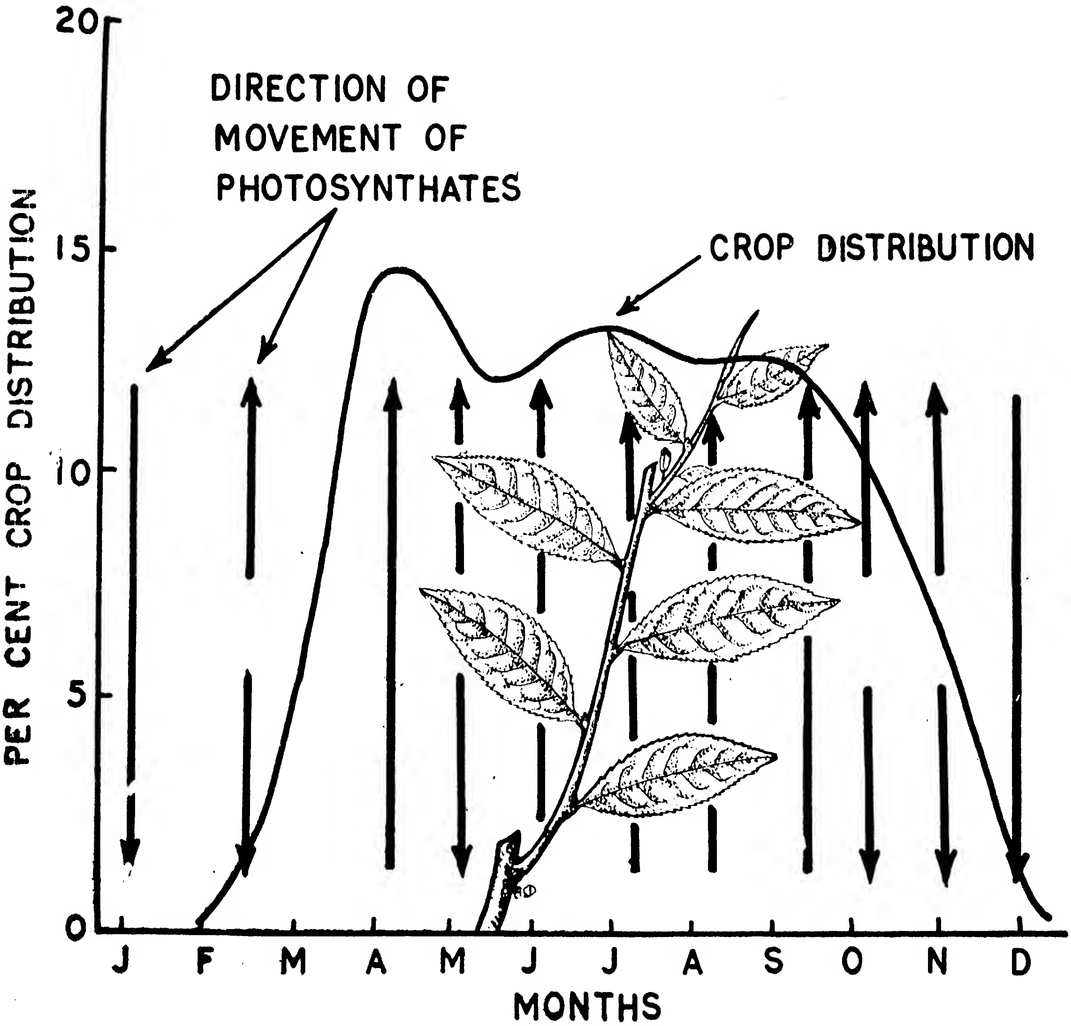
ANNUAL SCIENTIFIC REPORT

1980–81

TEA RESEARCH ASSOCIATION CALCUTTA



Our Cover

Direction of Movement of Photosynthates

TEA RESEARCH ASSOCIATION

Annual Scientific Report

The Tocklai Experimental Station of the Tea Research Association has pleasure in presenting the Annual Scientific Report (Part II) for the period 1st April, 1980 to 31st March, 1981 The Annual Administrative Report (Part I) of the Association for the same period is being issued separately from T.R.A., Calcutta.

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TOCKLAI EXPERIMENTAL STATION
JORHAT 785 008, ASSAM, INDIA

December 1981

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Contents

Director's Report

We have great pleasure in presenting the Annual Scientific Report of Tocklai Experimental Station, for the year 1980-81. It is a measure of Tocklai's strength that inspite of severe dislocation of normal life in the State, we have continued to function better than many other sister institutions in the region. Our research and advisory work during the year has enabled us to present this report before you.

The seventies have been a period of growth for the industry. The increment in yield has been 2.85% per annum compound. With the application of new research results, we hope that the rate of increment in the eighties will be even higher. We have several new Research results to report which we hope, will help the tea industry to cope with the unprecedented cost price squeeze.

Six outstanding clones from the vegetative selections have been put under district trials to evaluate their performance under different agroclimatic conditions. These will considerably augment the elite planting material to the member estates.

Direction of movement of photosynthates from the maintenance canopy to build the starch reserves, has provided a reliable physiological basis for timing the pruning and skiffing operations. Best results were obtained from these operations when starch reserves in the root had maximised and before their depletion begun for growth of shoots in early spring.

Nitrification inhibitors and slow release nitrogenous fertilisers were tried in green house and in field, to assess the possibility of reducing leaching/denitrification losses. Both increased the nitrogen uptake in 2-3 year old pot-grown tea plants but this better uptake was not reflected in higher yields. However, residual nitrogen build up in soil is encouraged when these additives are used.

A new pre-emergent herbicide "Oxyfluorofen" has been found to be very effective in controlling annual broad leaved weeds and grasses in tea. Granular pesticides were found to be quite effective against termites.

For designing drainage systems, data from a 5-year return period appear to be adequate. This was estimated to be 163 mm per day.

A 40 cm unit of Boruah Continuous Roller was constructed to carry on further trials. Pilot model of a Continuous Withering machine has also been constructed.

On the processing side, a new technique has been developed for manufacture of good quality lemon flavoured and spicy teas, as a hot beverage. Food colours are another new development for diversification of the uses of tea leaf.

For carrying out Tocklai's R & D work, the following senior staff members were responsible during the year.

Senior Staff

On the 31st March 1981, the Senior Staff consisted of :

Director.
Dr. N.K. Jain, M.Sc.Ag. (B.H.U.), Ph.D. (Illinois), C.P.Ag.(U.S.A.).

Adviser, T.R.A.
Dr. D.N. Barua, B.Sc.(Calcutta), Ph.D.(Cantab)

Advisory :

Located at Tocklai

Head of Department
Dr. T.K. Ghosh upto 5.8.80.

Advisory officer
Dr. D.N. Chakrabarty, B.Sc.Ag.(B.H.U.), Ph.D. (Agronomy) (Moscow)

Assistant Advisory Officer
Mr. N. Borpujari, M.Sc.Ag.(A.A.U.)

Assistant Training Officer
Mr. B.N. Gogoi, B.Sc.(Gauhati)

Agronomy :

Head of Department
Dr. F. Rahman, M.Sc.Ag. (Bihar), Ph.D.(I.A.R.I.) upto 31.5.80.
Dr. T.K. Ghosh, B.Sc.(Patna), Ph.D.(Cornell), Assoc. I.A.R.I. w.e.f. 6.8.80.

Second Agronomist (Weed Control)
Dr. V.S. Rao, M.Sc.Ag.(Osmania), Ph.D.(Cornell)

Estate Manager Cum Assistant Agronomist
Mr. A.K. Bhargava, M.Sc.(Agra)

Soils & Meteorology :

Head of Department
Mr. S.K. Dey, B.Sc.(Calcutta), Assoc. I.A.R.I.

Second Soil Scientist.
Dr. B. Singh, B.Tech.(Pant Nagar), M.Tech. (I.A.R.I.), Ph.D. (Newcastle)

Assistant Soil Scientists
Mr. N.G. Bhattacharjee, B.Sc.(Calcutta)
Dr. A. Sen, M.Sc.Ag., Ph.D.(I.A.R.I.)

One Assistant Soil Scientist located at Nagrakata Sub-station.

Botany :

Head of Department
Dr. H.P.Bezbaruah, M.Sc., Ph.D.(Gauhati)

Plant Physiologist
Dr. P.N. Rustagi, B.Sc.(Hons.), M.Sc., Ph.D.(Delhi)

Second Plant Breeder
Dr. I.D. Singh, M.Sc.Ag.(Agra), M.Sc.(Guelph), Ph.D.(Georgia)

Assistant Plant Physiologist
Dr. L. Manivel, M.Sc.Ag.(Madras), Ph.D.(California)

Entomology :
Head of Department
Dr. B. Banerjee, M.Sc. (Calcutta), M.S.(S.Illinois) Ph.D. (London), F.A.Z., F.R.E.S.(London)

One Assistant Entomologist located at Nagrakata Sub-Station.

Mycology :
Head of Department
Dr. G. Satyanarayana, B.Sc.(Hons.)(Andhra), Ph.D.(Madras), F.B.S., F.I.P.S.

Biochemistry :
Biochemist
Dr. S.D. Ravindranath, M.Sc.(Mysore), Ph.D. (I.I. Sc., Bangalore)

Assistant Biochemists
Dr. M.R. Ullah, M.Sc., Ph.D.(Gauhati)
Dr. M.N. Dev Choudhury, M.Sc.(Dibrugarh), Ph.D.(A.A.U.)
Dr. P.K. Mahanta, M.Sc. (Gauhati), Ph.D.(Gauhati)

Tea Tasting :
Tea Taster located at Nagrakata Sub-Station
Second Tea Taster
Mr. A.K. Das, B.A.(Gauhati)

Engineering Research & Development :
Head of Department
Mr. T.C. Baruah, B.Sc.(Hons.) (Gauhati), B.Sc. Mech.Eng.(B.H.U.), M.Sc.Mech.Eng. (Manchester)

Statistics :
Head of Department
Mr. A.K. Biswas, M.Sc.(Gauhati)

Agricultural Economics :
Agricultural Economist :
Dr. R.C. Awasthi, M.Com., LL.B., Ph.D.(Agra)

Nagrakata Sub-Station

Deputy Director
Mr. S. Basu, B.Sc.Ag.(Hons.)(Delhi), Assoc. I.A.R.I.

Advisory Officer, Dooars
Mr. B.C. Phukan, B.Sc.Ag.(Gauhati), A.I.F.C.

Assistant Advisory Officers, Dooars
Mr. R. Das Gupta, B.Sc.Ag.(Ranchi), M.Sc.Ag. (Bhagalpur)

Assistant Soil Scientist
Mr. A.K. Sengupta, B.Sc.(Hons.)(Calcutta)

Assistant Entomologist
Mr. S.C. Das, M.Sc.(Calcutta)

Tea Taster
Mr. R.P. Basu

Darjeeling Advisory Centre :
Advisory Officer
Mr. R. Padmanaban, B.Sc.Ag.(Madras)

Terai Advisory Centre :
Assistant Advisory Officer
Dr. S. Basu, B.Sc.(Calcutta), M.Sc.Ag.(Calcutta) Ph.D.(Calcutta)

Advisory Centres

Cachar Advisory Centre :
Advisory Officer
Mr. S.K. Sarkar, B.Sc.(Calcutta), B.Sc.Ag. (B.H.U.)

North Bank Advisory Centre :
Advisory Officers
Mr. B.C. Barbora, M.Sc.Ag.(I.A.R.I.)
Mr. B. Borthakur, M.Sc.Ag.(Gauhati)

Upper Assam Advisory Centre :
Advisory Officer
Mr. J. Chakravartee, M.Sc.Ag.(Gauhati)

Tripura Advisory Sub-centre :
Assistant Advisory Officer
Mr. S.C. Dey

Service Departments

Administration :
Administrative Officer
Group Captain K.R. Gopalan (Retd.)
Assistant Administrative Officer
Mr. B.S. Kotoky, B.A., LL.B.(Dibrugarh)

Accounts :
Accounts Officer
Mr. O.P. Shukla, B.Com.(Lucknow), A.C.A.
Assistant Accounts Officer
Mr. P.C. Adhikari, M.Com.(Calcutta), I.C.W.A. —upto 20.6.80.

Library & Publication :
Librarian & Assistant Publication & Information Officer
Mr. J.N. Sharma, M.A.(Gauhati)

Maintenance :
Assistant Station Engineer
Dr. H.K. Barua, M.Tech. (Structural Engg.), Ph.D.(Kharagpur)

Medical :
Medical Officer
Dr. (Major) S.W. Rohman, M.B.B.S.

TRAINING & COURSES FOR PLANTERS

Six weeks' Training in V.P. for supervisors

1st course from 1st May to 15th June 1980.

2nd course from 22nd October to 30th November 1980.

Three months Training for supervisors

1st course from 22nd October 1980 to 31st January 1981.

2nd course from 23rd March to 20th June 1981.

Field Management course for planters

1st course from 15th September to 18th September 1980.

2nd course from 22nd September to 25th September 1980.

Drainage course for planters at Nagrakata

1st course from 9th February to 14th February 1981.

2nd course from 16th February to 21st February 1981.

Tea Economics course for planters

1st course from 18th August to 21st August 1980.

2nd course from 25th August to 28th August 1980.

VISITORS

Mr. A.K. Wason, Consultant (Tea), N.E. Council, Shillong on 30.5.80.

Mr. T.P.S. Teotia, Director, Indian Lac Research Institute, Ranchi on 2.6.80.

Major General J.S. Nanda, HQ, Eastern Command on 3.6.80.

Mr. M.K. Bezboruah, Secretary, Delhi Administration (MHA) on 4.6.80.

Mr. Anand Prakash, Assistant Commissioner, Dispur on 4.6.80.

Miss Emily Das, Assistant Commissioner, Sibsagar on 4.6.80.

Mr. A.K. Sanyal, Development Manager (R & D), Rallis India Ltd., Calcutta on 11.6.80.

Mr. C.N. Phookan, District Employment Officer, Jorhat on 17.6.80.

Dr. B.N. Chatterjee, Dean, Faculty of Agriculture, BCKVV, Kalyani on 20.6.80.

Dr. S. Ramanujam, Head, Genetics Durson, IARI, New Delhi on 20.6.80.

Dr. S.K. Sinha, Professor of Plant Breeding, Orissa Agricultural University on 20.6.80.

Mr. R.N. Haldipur, Lt. Governor, Arunachal Pradesh on 11.8.80.

Mr. Z. Thangseia, Director of State Transport, Arunachal Pradesh, Rowriah on 11.8.80.

Mr. R.K. Ghosh, Chief Executive, Scott & Saxby Ltd. on 9.9.80.

Dr. Panjab Singh, Assistant Director General, ICAR, New Delhi on 12.9.80.

Dr. S.K. Basu, Director, Central Mechanical Engineering Research Institute, Durgapur on 19.9.80.

Dr. M.G. Srivastava, Commercial Manager, ICCI, Madras on 22.9.80.

Dr. E. Hamaya, Head of Mycology, National Research Institute of Tea, Japan on 23.9.80.

Mr. Clive Coni, IDA Consultant, Indonesia on 14.11.80.

Mr. George Gitungo, Chief Technical Officer, Kenya Tea Development Authority on 14.11.80.

Mr. H.C. Barman, Addl. Labour Commissioner, Gauhati on 14.11.80.

Major General S.D.S. Yadava, GOC, 101 Area on 8.1.81.

Brigadier W. Lobo, Cdr., 21 Corps Asty Bdl. on 4.2.81.

Lt. Colonel S.P. Malhotra, 126 AD Regt. on 4.2.81.

Capt. P. Michael, 126 AD Regt. on 4.2.81.

Mr. G. Chatterjee, Chief Administration, CSIR, New Delhi on 5.2.81.

Brigadier R.K. Singh, HQ 4 Corps on 17.2.81.

Mr. M.S. Chadha, Head, Bio-organics, Bhaba Atomic Energy Research Centre, Bombay on 28.2.81.

Dr. S.C. Pakrashi, Deputy Director, Indian Institute of Experimental Medicine on 28.2.81.

Dr. V.B. Bhatnagar, Professor & Head of Plant Physiology, B.H.U. on 6.3.81.

Colonel Ranjit Singh, Col. IC Adm., HQ 101 Area on 7.3.81.

VISITS

The Director visited the following :

Delhi on 8th/9th May to attend ISI Wood Products Sub-Committee; Calcutta on 10th May to attend Dynamics of Rural Change-Seminar of USIS at Calcutta; Mysore from 12th/13th May to attend Co-ordination Council Meeting of Biological Group of CSIR Laboratories; Tezpur on 14th May to attend ASC Meeting of North Bank East; Dibrugarh on 15th May for a talk at AIR Dibrugarh; Calcutta/Delhi on 22nd/23rd May for a Meeting with Secretary (ED) Ministry of Commerce; Calcutta from 15th to 18th June to attend Agricultural Sub-Committee Meeting, Economics Advisory Committee Meeting and Scientific Advisory Committee Meeting; Calcutta on 23rd June to attend Council of Management Meeting; 21st July at Calcutta to attend TRA Executive Committee Meeting; Dibrugarh on 22nd July to attend ASC II Meeting; New Delhi on 9th August for NBRI Officer's assessment; Palampur on 11th & 12th August to attend meeting of CSIR Committee on Complex for H.P.; Calcutta on

22nd August for TRA discussions regarding Conference & Non-Traditional tea areas; Calcutta on 30th August for CMERI discussions on Co-ordinated Machine Development Project and Tea Board discussions on Instant Tea; 1st September at Dharwar to conduct Ph.D. viva voce of an Agricultural University student; Calcutta on 17th September to attend Executive Committee Meeting; 1st October at Delhi for a meeting with Electronics Commission & CSIO regarding Instrumentation project; 6th & 7th October at Calcutta to attend TRA Executive Committee Meeting; 10th to 12th November at Calcutta for TRA Executive, Engineering & Economic Advisory Committees Meetings; Calcutta on 3rd & 4th December to attend TRA Council of Management Meeting; 5th & 6th December at Hyderabad to attend CSIR Co-ordination Council of Biological laboratories; Calcutta on 21st December to attend Tea Research Liaison Committee Meeting of Tea Board; New Delhi on 22nd & 23rd December for CSIO discussions regarding project on Instrumentation for funding by Electronics Commission and discussions with Minister of State for Commerce regarding Tea Industry in U.P./H.P.; Calcutta on 5th January'81 to attend Council of Management Meeting; Calcutta on 12th & 13th January to attend ITA International Seminar on Tea; Calcutta on 28th/30th January to attend Annual General Meeting of TRA and Tea Research Liaison Committee Meeting of Tea Board; New Delhi on 4th February to attend CSIR Biological Research Committee Meeting; Calcutta on 5th February to attend ISI Tea Sub-Committee Meeting; Darjeeling & Nagrakata on 6th/8th February to visit TRA Advisory Centres; Nagrakata on 9th February for Drainage course; Calcutta on 16th/17th February for Council of Management Meeting; Calcutta on 18th February to attend Engineering Sub-Committee Meeting; Silchar on 24th/26th February to attend SVBITA Annual General Meeting & TRA Meeting of ASC.

Group and individual visits were made to the following places

Mr. T.C. Baruah visited Calcutta from 10.11.80 to 19.11.80 to attend Engineering Sub-Committee Meeting and he visited Durgapur and Calcutta from 15.2.81 to 19.2.81 for visiting CMERI and attended Engineering Sub-Committee Meeting.

Dr. G. Satyanarayana visited Madras from 28.12.80 to 3.1.81 to attend Madras University Golden Jubilee Celebrations.

Dr. V.S. Rao visited Bhubaneswar from 21.7.80 to 23.7.80 to attend the Annual Conference of Indian Society of Weed Science and visited new Delhi on 27.3.81 to atend a meeting of Herbicide Panel of the General Insecticides Board.

Mr. A.K. Biswas visited Calcutta Indian Statistical Institute of Regional Computer Centre from 22.9.80 to 24.9.80.

Dr. H.P. Bezbaruah visited Calcutta on 17.6.80 to attend Agricultural Sub-Committee Meeting and New Delhi from 8.7.80 to 11.7.80 to attend Financial Management and Research & Development Course at CSIR.

Dr. M.N. Dev Choudhury visited Cochin from 10.12.80 to 13.12.80 to attend the Third Plantation Crops Symposium. He also visited Bangalore from 14.12.80 to 18.12.80 to attend the Federation of Asiatic and Oceanic Biochemists Conference and Golden Jubilee Symposium of the Biological Society and visited Mysore Food & Technological Research Institute, Mysore on 19.12.80.

Library & Publication

The Tocklai Central Library supplied regularly books and other publications to the eleven departments and outstation branch libraries. During this period one hundred & eleven new books were added to the Library raising its total number of books to 4836. This year the Library subscribed to 6 new journals raising the number of subscribed journals to 158 from India and abroad. One hundred and forty two journals were received on free and exchange basis.

Library statistics

Journal volumes received on subscription basis	..	893 Nos
Journal volumes received on free & exchange basis	...	1275 Nos
Pamphlets & Bulletins	...	210 Nos.
Photocopies	...	5 Nos.
Projection slides	...	134 Nos.
Translated articles	...	8 Nos.
Reprints	...	10 Nos.
Publication issued to departments	..	1564 Nos.
Journal volumes bound	..	63 Nos.
Publications consulted in the Library	..	1890 Nos.

Library service

Library services were extended to students, research scholars, teachers, scientists and personnels of the Government not connected with Tocklai, in addition to serving our own scientists. Students and teachers from the Assam Agricultural University, Engineering College and other local colleges, research scholars and scientists from Regional Research Laboratory, Jorhat have used the Library during the year. One-year trainees, V.P. Trainees from Tea Research Association member estates have also utilised the Library throughout the year. To meet the regular demand of Photocopying facilities a "Plain Paper Copier" has been installed in the Library Department at the end of the period under review.

Library stock-taking

Physical verification of library book stock has been undertaken.

Documentation & Information

Two Bulletin of Documentation on Tea and three Documentation Lists were circulated among the Departments. One Documentation List was split up on subject basis and separate lists were circulated among the respective Departments.

Accession lists, showing the titles of publications received by the Library were also circulated among the Departments.

Cataloguing and classification of books are continuing.

Press cuttings relating to Tea and allied subjects and other important topics have been made. Various reference querries were answered. Hundreds of references have been added to the "Bibliography on Tea" in card form.

Publication

1. Two & A Bud, Vol. 27, No. 1, June 1980.
2. Tocklai News, No. 11.
3. Annual Scientific Report 1979-80.
4. Engineering Research & Development Department Quarterly Reports for quarters ending March '80, June '80 and Sept-Dec'80 (cyclostyled).
5. **T.E. Serials**
   - (a) No. 7/2 Top pruning (revised).
   - (b) No. 8/4 Black rot (revised).
   - (c) No. 17/6 Installation of Meteorological Instruments and Meteorological Observations (revised).
   - (d) No. 62/2 Blister blight (rewritten).
   - (e) No. 80/3 Weed control in tea (rewritten).
   - (f) No. 189/1 Uprooting, soil rehabilitation & replanting of tea (rewritten).
   - (g) No. 200 Pruning cycles (new).
   - (h) No. 83/2 Factory requirements for 500000 kg Factory in the plains (rewritten).
   - (i) No. 201 Plucking (new).
   - (j) No. 1/3 Encyclopaedia of tea (rewritten).
   - (k) No. 75/9 Index of Encyclopaedia of tea serials issued upto July '80 (revised).
   - (l) No. 118 Vegetative Propagation—Part I (revised).

Advisory

GENERAL

The Advisory Officers continued to visit member estates and organised ASC meetings and seminars. The demand for the advisory services were as keenly sought as was in the past.

The Advisory Department also organised for the first time field demonstrations-cum-seminars on the current recommendations of Tocklai on plucking and pruning for Sirdars/supervisory staff of tea estates.

ADVISORY VISIT

Due to stoppage of services to defaulting member estates, majority of whom incidentally were more keen on advisory visits and conditions prevailing in Assam the number of visits declined in Dooars and South Bank of Assam. The number of advisory visits are shown in Table 2.01.

AREA SCIENTIFIC COMMITTEE MEETING & SEMINAR

The Area Scientific Committee meetings and seminars held during the year in different areas are shown in Table 2.02.

LECTURE COURSES

The following lecture courses were organised by the Department with the help of specialist officers

Table 2.01. *Advisory visits paid to the member estates during 1979-80 and 1980-81*

District	Total No. of Member estates		No. of Member estates visited during		Total No. of visits paid during	
	1979-80	1980-81	1979-80	1980-81	1979-80	1980-81
South Bank (including Upper Assam)	366	340	269	243	497	398
North Bank	94	94	88	87	178	180
Cachar & Tripura	92	116	88	115	290	296
Dooars	125	120	107	113	352	255
Terai	43	41	40	37	152	141
Darjeeling	82	70	70	63	148	132
Total	802	781	662	658	1617	1402

Table 2.02. *Number of ASC meeting and seminars on different topics and the number of planters attending*

Area	Date	Topic of seminars	No. of Planters attended
South Bank (Assam) East (1)	24.3.81 21.7.80	Agriculture, Botany & Soils Agriculture & Plant Protection	80 92
South Bank (Assam) Central (2)	22.7.80	Manufacture, Plant Protection & Agriculture	69
South Bank (Assam) West (3)	25.6.80 30.9.80	Engineering & Manufacture Botany	47 47
North Bank (Assam) East & West	12.6.80 26.8.80	Plant Protection Agriculture, Botany & Soils	37 13
Cachar	26.2.81	Agriculture, Botany & Soils	69
Dooars	26.5.80 18.8.80	Engineering & Manufacture Agriculture & Soils	83 85
Terai	27.5.80 19.8.80	Engineering & Manufacture Agriculture & Soils	41 50
Darjeeling	26.5.80	Plant Protection	66

Field Management Courses : Two course (each of 4 days duration) were held during the year and 29 planters attended.

Surveying & Drainage Course : As the situation did not permit holding of the courses at Tocklai, two courses (each of 6 days duration) were held at Nagrakata. As accommodation could not be provided to the coursees who intended to come from other areas out-side Dooars, on 15 planters could attend the courses who could make their own arrangements.

TRAINING COURSES FOR SUPERVISORY STAFF OF TEA ESTATES

The Advisory Department of Tocklai introduced from this year, for the first ttime, training courses the supervisory staff of tea estates. Practical demo

trations-cum-seminars were organized for Sirdars and other field staff on tipping and plucking during April-June 1980 in 30 centres covering most areas of North East India. These demonstrations were attended by 1229 estate personnel including executive staff. The regionwise distribution of participants is given in Table 2.03.

Table 2.03. *Regionwise participation in tipping and plucking demonstrations*

Region	Total number of demonstrations	No. of participants
Upper Assam	8	289
South Bank	6	230
Cachar	3	92
Tripura	2	27
North Bank	2	109
Dooars	7	378
Terai	2	104

These demonstrations were very well-received by the industry and many requests have been received to continue the programme with other items of field management practices.

The programme was continued with practical demonstrations on Pruning and Skiffing during November-January last. While the number of participants on these demonstrations increased considerably in Upper Assam, the number were down in the Dooars since estates were badly affected by labour unrest during this period. Unfortunately the programme in Cachar and Tripura had to be cancelled due to unavoidable circumstances. The number of participants in different regions is given in Table 2.04.

Table 2.04. *Regionwise participation in pruning and skiffing demonstrations*

Region	Number of demonstrations	No. of participants
Dooars	7	257
Terai	3	109
South Bank	7	240
Upper Assam	10	483
orth Bank	7	157

This has been acknowledged as one of the most useful services extended by the Advisory department in recent years to the workers of the industry at the grass root level.

In order to give more coverage, tipping and plucking demonstrations were conducted again in the Dooars and Terai during March 1981. The number of participants is given in Table 2.05.

Table 2.05. *Areawise participation in tipping & plucking demonstrations during March, 1981*

Area	No. of demonstrations	No. of participants
Terai	2	36
Dooars	7	197
Total	9	233

DISTRIBUTION OF CUTTING

The details of distribution of cuttings, generative clones and seeds from Tocklai (Borbhetta) and various outstations to member estates, Tea Board and other State Governments are given in Table 2.06.

Table 2.06. *Distribution of cuttings, generative clones and seeds from Tocklai and outstations.*

Tocklai & Outsations	V.P. Cuttings	Scions	Generative Cuttings	Generative Scions	Plants	Seeds in kg
Tocklai (S. Bank)	9,17,602	6,539	12,845	—	1,56,646	1,180
North Bank	1,26,355	4,855	20,316	2,470	—	—
Cachar	3,74,950	—	10,000	—	—	—
Dooars & Terai	2,63,840	1,620	21,100	645	—	44
TOTAL	16,82,747	13,014	64,261	3,115	1,56,646	1,324

CLONAL PROVING STATION (DARJEELING)

Mini Manufacture was carried out on 35 occasions and total of 467 samples were sent for evaluation.

Weeping love grass was planted in about 100 m^2 of area and the total weight of green mulch was 45 tons/ha in the year following planting.

COMMENTS ON AGRICULTURAL PRACTICES

Land Planning and Drainage

Increasing awareness of the importance of contour survey and drainage has been reflected in increase in the areas being surveyed and drainage improved. From a sample survey of 20% responding estates, it was found that in mid and lower South Bank about 30% more area was contour surveyed and in about 15% more area drainage was improved compared to 1979. Interceptor drains with proper outlets on the slopes were made in about 20% more area in Darjeeling compared to last year.

Pruning Cycle

There has been a general shift towards quality-oriented pruning cycles with reduction in unprune/lighter skiff areas and shortening of pruning cycles. This trend is more apparent in Assam Valley both in South and North Banks.

Apart from grouping of sections for drawing up pruning schedules at estate level, it is seen that some companies have grouped their estates for crop and for quality; little longer cycles were being followed in estates

going for crop while 2/3 year cycles avoiding/unprune/ lighter skiffs were being followed in the quality estates. The benefits accrued from such grouping need be observed over the cycle.

The need for leaving sufficient new wood at the time of pruning has been well recognised and became a standard practice in all the districts. The practice of keeping about 7/8 cm new wood above the knots was adopted by some estates where it was not immediately possible to go for a compromise pruning for removal of knots.

The Advisory Officers continued to emphasise the need for a rest period before light pruning, particularly where longer pruning cycles have been followed in the past years.

Rejuvenation

Rejuvenation and infilling continued to be popular amongst many estates in Terai, Dooars and Cachar, whereas in North Bank medium pruning was preferred to rejuvenation pruning. After both these operations tea areas, by and large, were consolidated in respect of shade, drainage and infilling.

In mid and lower South Bank though medium pruning was preferred to rejuvenation pruning areas under both operations showed 30% and 8% increase respectively over the previous year.

In Darjeeling rejuvenation pruning was taken up in about 13% less area than in the previous season. Follow-up measures were however carried out properly.

Young Tea

Though bush population continued to remain between 14,000 to 20,000 per hectare, a tendency to limit the bush population to a lower range i.e. between 14,000 to 16,000 per hectare has been observed particularly in Upper Assam.

The practice of pegging has remained popular both in the replanted and extension areas of Assam, with some declining trend in the extension areas of mid and lower Assam. However, conventional method of bringing up young tea has been practised in general all over North East India.

In order to force lateral growth in recently planted tea, some estates in Assam and Cachar tried debudding of the apical and all axillary buds leaving only those remaining upto 15 cm from the ground level. Once the laterals made sufficient growth, these were either further debudded, pegged or decentered. Initial decentering or lung pruning is avoided in this method. Although it appears promising, results from other areas will have to be awaited for wider application.

Planting

The popular planting materials were TV 1, 17, 18, 19, 20, P 126A, Teen Ali 17/1/54, and biclonal seed stocks 449 and 450. The following clones also receive attention for planting in different areas:

TV 10, 14, 16, Teen Ali 8, 80, S 3A3, N 43(T351, P32 and Seeds like Dangri Manipu (in drier areas).

In Cachar the rate of replanting decreased by abou 30% compared to last year, but replacement plantin (replacing the uneconomic areas) increased by abou 35%. In mid and lower South Bank both extensio and replantation areas increased by 40% and 60% respectively, over last year. In North Bank, whereve land was available extension planting was preferred t replanting and in the process marginal areas also wer planted by a few estates due to shortage of good virgi areas for extension planting. The same trend wa observed in Dooars also. The area planted o durin the season under report in Darjeeling was 50% le than the previous year. Use of seedlings of Assan jats for planting in Darjeeling has gone down.

Due to the continuous efforts of the Advisory Offi cers the practice of infilling, especially in young te areas, has become popular and in Cachar and mid an lower Assam, about 15% and 9% more areas respec tively were brought under infilling programme, compa red to last year. In Darjeeling Nanda Devi seedling were used for infilling. The common defects in plan ting have been shallow pits and deep planting in con trast to our recommendation of 45 cm deep pits with further loosening of the soil to 15 cm in heavy soils an the bhetis remaining flush with the ground.

Mulching

Mulching of young tea has become a standar practice in most of the estates in North East India. Com mon mulching materials were loppings of Guatemal and Citronella grasses, water hyacinth and at time succulent scrub jungles. Depending on the elevatio Guatemala and Weeping love grasses for mulchin were planted by many estates in Darjeeling. Are under mulching increased by 17% in mid and lowe Assam and by 8% in Cachar during the year. Th increased cost of mulching has, however, led to thinne mulch compared to previous years.

Plucking

In general standard plucking continued to be popu lar. However, some estates went in for black pluckin during the early part as reported from the Dooars. large number of estates showed a tendency towar little finer plucking with an aim to improve qualit An attempt to pluck fine in earlier flushes led to blac plucking in some of the quality-conscious estates.

Compared to the last season there has been a sh towards raising the table either at the end of the seaso or at the beginning or end of the first flush in the ye of unprune. Plucking below the table and too mu

creep due to faulty plucking were also noticed and corrected in the pruned sections of Darjeeling.

Vegetative Propagation

In Terai, Cachar and Tripura stress on clonal material rather than on seed has been continuing.

Problems like heavy soil, leaves touching ground, imperfect light penetration, uneven growth of plants, over-damp condition of soil etc., were faced and necessary corrective advice was offered to the concerned estates. In Tripura, an estimated 8 lac cuttings were planted out in ten member estates. In Darjeeling cuttings of certified clones formed the major part of nursery.

In mid and lower Assam cleft grafting remained more popular than bud grafting, though mortalities of scions due to delayed and, at times, sudden removal of polythene bags were noticed. Cleft and bud grafting were taken up by many estates of Darjeeling.

A large number of bushes were selected all over North East India under District Clonal Selection Scheme and some of these were already put in field trials at different locations.

Manuring

Increased prices of fertilisers and their late availability led to application of less quantity of fertilisers. This was especially true of nitrogenous fertilisers. Rock-phosphate has been extensively used in mature tea and in some cases Dicalcium phosphate and even Diammonium phosphate were also used.

Application of potash according to available soil potash status has become an accepted practice. Foliar application of potash during the dry periods has been increasingly practised in Assam. Autumn application of potash has also been tried in an increasing number of Assam estates.

Though foliar application of zinc in unpruned and skiffed teas has proved its merit in North East India, only a limited number of estates in mid and lower Assam and Darjeeling sprayed zinc.

Weed Control

Use of pre-emergent herbicides has gained popularity, especially in young tea. Non-availability of post-emergent herbicides like Glyphosate and MSMA caused a set-back in controlling difficult weeds. Planters are becoming more conscious about proper dosage of both pre and post-emergent herbicides and adequate quantities of herbicides were applied in most of the cases. The area under chemical weed control increased by 15% and 10% respectively during the year under report in mid and lower Assam and Darjeeling.

Shade

Most of the estates have taken keen interest in raising and maintaining shade. Inspite of severe pest problem to young permanent shade trees, estates could establish shade trees in newly planted areas by resorting to regular spraying programme. In addition to the above, in Dooars biotic interference like cattle grazing and illegal cutting of shade trees have become a problem. In North Bank a growing awareness to establish shade at the time of planting rehabilitation crop in uprooted areas has been noticed. In mid and lower Assam a number of estates are establishing green crop shade in the newly planted tea areas. Though the shade improvement work is continuing in more estates, the area thus improved showed a decline of about 25% compared to last year in mid and lower Assam. In Darjeeling green crop shade of *Crotalaria* and *Priootrpis* was established in heavy pruned areas in lower elevation. All over North East India the planters are eagerly awaiting for the introduction of new shade trees. At present *Albizzia odoratissima*, *Albizzia lebbek* and *Acacia lenticularis* are being planted and a few estates are also trying *Albizzia chinensis*, *Dalbergia sericia* and *Derris robusta*.

A number of estates are trying a new fuel tree Koo Babul (*Leucaena leucocephala*), reportedly the fastest growing tree in the world.

Inclination towards vegetative propagation of *Indigofera* airlayers for raising temporary shade trees has been noticed in most of the tea districts of North East India.

Pest Control

In Upper Assam flushworm was fairly widespread during the early part of the season, in mid and lower Assam and North Bank green fly and thrips were most widespread till mid June. In Darjeeling thrips infestation was severe, especially for pruned sections during May/June and August/September. In Cachar, Tripura and Dooars, infestation of pests were comparatively less than in the previous year. In the Dooars and Terai severe infestation of thrips and red slug caterpillar were noticed in certain pockets. Other pests of significance in Assam were red spider and other mites, looper caterpillar and stem borers. Damage caused by white ants has been increasing over the seasons and most of the estates are taking up termite control measures in the year of pruning. In Dooars cockchafer caused a major problem in young tea areas which was controlled by application of Endosulfan @ 1 part in 300 parts of water (250 ml per plant).

Disease Control

Both red rust and black rot incidence was lower this season and control measures were taken timely wherever necessary. Blister blight and Red spot diseases caused extensive damage in Darjeeling for a short spell during monsoon.

Results of some of the experiments conducted by this Department in member estates are given below:

1. YOUNG TEA MANURING (YTD)

Seven experiments on dose and frequency of YTD application to young tea are continuing in different regions of North-East India. These experiments were laid out between 1976 and 1977 and treatments were first imposed in 1977 and 1978 respectively. The results for two experiments not reported last year are given in Table 2.07.

Table 2.07. *1980 yield of young tea in KMTH with different doses of YTD fertilizers.*

YTD/Plant in g	AS 144				C 49			
	2-splits	3-splits	4-splits	Avr.	2-splits	3-splits	4-splits	Avr.
40	2812	3287	3788	3296	2005	2156	1954	2038
60	2936	3220	3807	3321	1959	1934	2308	2067
80	3142	3356	4035	3511	2400	2652	2787	2613
100	3763	3749	3976	3829	2290	2582	2619	2497
120	3530	3587	4104	3740	2292	2184	1814	2097
Average	3237	3440	3942	–	2189	2302	2296	—

C.D. (P=.05)		C.D. (p=.05)	
,, ,, Split	= 164	.. ,, Split	= NS
,, ,, Level	= 211	,, ,, Level	= 128
,, ,, Split×Level	= 366	,, ,, Split× level	= 597
C.V.%	= 7.25	C.V.%	=18.51

The data indicate that in AS 144 in the third year, YTD at 100 g/plant significantly increased crop over other treatments. The difference between 100 g and 120 g YTD is not significant. In general, four splits gave higher yield at all doses compared to two or three splits and 100 g YTD per plant in four splits appeared to be the best treatment.

In case of Expt. C 49 which is in the second year, YTD at 80 g/plant in four splits gave the best result. More than 80 g YTD/plant depressed the crop significantly. Within the range of 60 to 100 g YTD per plant higher the split more was the crop except when 60 g was applied in three splits.

2. IRRIGATION

The data for the two years, 1979 and 1980 of the irrigation experiment at Dam Dim TE (D63), laid out in 1976 are presented in Table 2.08. The quantum of water requirement for cold weather irrigation was computed statistically from long-term crop-weather data and the entire requirement was applied at different intervals with varying rates in some cases. The date of first irrigation also varied in some treatments. In one treatment 14 cm less water was applied and it was distributed between December to March.

In the unpruned year (1979) all irrigation treatments produced significantly higher crop over control

Table 2.08. *Effect of irrigation on yield (KMTH) in 1979 and '80*

	1979			1980		
	S1 (UP)	S2 (UP)	$\bar{x}$	S1 (LP)	S2 (LP)	$\bar{x}$
M1 = No irrigation (control)	2066	1938	2002	1554	1537	1546
M2 = 54 cm in 9 instalments	2531	2550	2540	1638	1599	1618
M3 = 54 cm ,, 8 ,,	2545	2658	2601	1686	1729	1708
M4 = 54 cm ,, 12 ,,	2912	2924	2918	1621	1700	1660
M5 = 40 cm ,, 7 ,,	2683	2117	2400	1656	1580	1618
C.D. (P= .05) for Irrigation treatment means			=	236		NS
CV%			=	3.76		6.76

and the trend of earlier years producing highest yield with 54 cm irrigation divided into 12 equal applications between mid November of end April (M_4) continued. In the light pruned year of 1980, however, irrigation did not result in any significant increase in yield.

Due to unavoidable reasons the trial had to be discontinued from 1981.

3. BRINGING UP OF YOUNG TEA

Two experiments one each in Arcuttipur TE (C 51) in Cachar and Haldibari TE (D 70) in the Dooars were started in 1977 to find out the most suitable method of bringing up young tea. The results are shown in Tables 2.09 and 2.10 respectively.

(i) Experiment C 51

This experiment was conducted at Arcuttipur TE in Cachar in 1977 in a Chandkhira seedling section planted in June/July, 1977. The yield data for 1980 are presented in Table 2.09.

Table 2.09. *Effect of different methods of bringing up on yield of young tea*

Treatment	Yield KMTH in 1980
1. – Cut across at 35 cm from the ground, centre out between 10–15 cm leaving 2-3 side laterals, pluck at 50 cm, frame forming prune after 12–18 months then follow step up plucking. (1980 UP))	1424
2. –· Cut across at 35 cm from the ground and centre out between 10–15 cm. Pluck at 50 cm, follow step up plucking for two seasons and then review. (1980 UP)	2062
3. — Pegging—follow step up plucking initiating from 40–45 cm. Cut across at 35–40 cm after one full season and light centre clean out. Then follow step up plucking. (1980 UP)	1604
4. — Centre out between 10–15 cm leaving 2–3 side laterals, peg, follow step-up plucking initiating from 40–45 cm for one full season and then review. (1980—UP)	1458
C.D. (P =.05)	155
CV%	6.89

The treatment consisting of cut across at 35 cm from the ground and centre out between 10-15cm pluck at 50 cm, step up plucking (T_2) continued to give significantly higher crop over other treatments.

(ii) Experiment D 70

This experiment was initiated in 1977 at Haldibari TE in the Dooars in a TV1 section, planted in July, 1977. The yield for the year 1980 are presented in Table 2.10.

Table 2.10. *Effects of different methods of bringing up on yield of young clonal tea.*

Treatments	Yield KMTH in 1980
1. — Cut across at 35 cm from the ground, centre out between 10–15 cm leaving 2–3 side laterals. Pluck at 50 cm, frame forming prune after 12–18 months, then follow step up plucking (1980-UP).	2452
2. — Cut across at 35 cm from the ground and centre out between 10–15 cm. Pluck at 50 cm, follow step up plucking for two seasons and then review (1980-LP).	1439
3. — Pegging—follow step up plucking initiating from 40–45 cm. Cut across at 30–45 cm after one full season and light centre out, then follow step up plucking. (1980–UP).	2651
4. — Centre out between 10–15 cm leaving 2–3 side laterals, peg, follow step up plucking initiating from 40–45 cm for one full season and then review (1980–UP).	2442
C. D. for treatment means (P = .05)	209
CV%	6.76

During 1980, pegging followed by cut across at 30-45 cm and centre cleaning after one full season, step up plucking (T_3) yielded the highest crop. The treatments T_1, T_3, & T_4 which at par significantly outyielded the treatment T_2 comprising of first year cut across (35 cm) with centring (18-15 cm) and subsequent step up for full two seasons.

4. REJUVENATION EXPERIMENTS

(i) Experiments D 43 and D 46

The yield data for 1978-1980 of two experiments laid out in Dalgoan (D 43) and Rydak (D 46) in the Dooars in 1972 are presented in Table 2.11 and Table 2.12 respectively.

Table 2.11. *Effects of rejuvenation treatments on 1978–80 yield.*

Treatments	Yield KMTH		
	1978(LS)	1979(LP)	1980(UP)
1= No rejuvenation (control)	1565	1307	1442
2= Cold weather prune and infill in the spring with a vigorous clone at double the number of plants per vacancy plus one.	1997	1548	2161
3= Cold weather prune and infill in the spring with a vigorous clone at double the number of plants per vacancy plus one, also interplant to make into hedge.	2590	1996	2611
4= Prune in July/August and infill in the autumn as in T_2	1996	1541	1937
5= Prune in July/August and infill in the autumn as in T_3	2167	1742	2343
C. D. for treatment means (P =.05)	316	287	154
CV%	10.89	6.36	5.22

The data show that at Dalgoan in light skiffed (1978), light pruned (1979) and unpruned (1980) years the cold weather prune with interplanting treatment (T_3) gave the highest crop. Other rejuvenation treatments also yielded significantly more than the control.

Table 2.12. *Effect of rejuvenation treatments on 1978–80 yield.*

Treatments	Yield KMTH		
	1978 (LS)	1979 (LP)	1980 (UP)
1= No rejuvenation (control)	1488	1314	1921
2= Cold weather prune and infill in the spring with a vigorous clone at double the number of plants per vacancy plus one	2109	1514	2512
3= Cold weather prune and infill in the spring with a vigorous clone at double the number of plants per vacancy plus one, also interplant to make into hedge	2281	1488	2631
4= Prune in July/August and infill in the autumn as in T_2	1880	1352	2380
5= Prune in July/August and infill in the autumn as in T_3	2192	1582	2799
C.D. for two treatments means (P = .05)	123	NS	114
CV%	4.40	6.69	3.32

In the Rydak trial (D 46) pruning both in cold weather and in rains with interplanting (T_3 & T_5) gave significantly the highest crop over other rejuvenation treatments in the light skiffed (1978) and unpruned (1980) years. However, in the light pruned year the differences between treatments were not significant. In the unpruned (1980) year, both the treatments (T_3 & T_5) gave significantly higher crop over other treatments and the difference between themselves was also significant.

(ii) Experiment TR 5

The yields for three years , i.e. 1978 to 1980, from the trial laid out at Gangaram TE in Terai in 1972 are given in Table 2.13.

Table 2.13. *Effects of rejuvenation treatments on 1978–80 yield.*

Treatments	Yield KMTH		
	1978 (LS)	1979 (LP)	1980 (UP)
TR_1 = No rejuvenation (control)	2683	1836	2095
TR_2 = Cold weather prune and infill in the Spring with a vigorous clone at double the number of plants per vacancy plus one	2705	2110	2483
TR_3 = Cold weather prune and infill in the spring with a vigorous clone at double the number of plants per vacancy plus one also interplant to make into hedge	3132	2439	2743
TR_4 = Prune in July/August and infill in the autumn as in T_2	2872	2288	2665
TR_5 = Prune in July/August and infill in the autumn as in T_3	3119	2207	2677
C. D. for treatments means (P =.05)	122	293	144
CV%	2.98	4.85	3.19

In the light skiffed (1978), light pruned (1979) and unpruned (1980) years pruning in cold weather with interplanting (T_3) gave the highest yield although

the difference in yield with pruning in the rains and interplanting (T_5) was not significant in any year.

(ii) Experiment AS 128

The yield data for three years, 1978 to 1980, of the experiment laid out at Tara TE in South Bank, Assam, in 1974 are given in Table 2.14.

Table 2.14. *Effects of rejuvenation treatments on 1978-80 yield.*

Treatments	Yield KMTH		
	1978 (LP)	1979 (UP)	1980 (DS)
TR_1 = No rejuvenation (control)	1764	2327	2318
TR_2 = Cold weather prune and infill in the spring with a vigorous clone at double the number of plants per vacancy plus one	1775	2594	2591
TR_3 = Cold weather prune and infill in the spring with a vigorous clone at double the number of plants per vacancy plus one also interplant to make into hedge	1994	2996	2944
TR_4 = Prune in July/August and infill in the autumn as in T_2	1740	2613	2604
TR_5 = Prune in July/August and infill in the autumn as in T_3	1728	2705	2654
C. D. for treatments means (P = .05)	NS	361	163
CV%	7.70	4.91	4.41

In the light pruned (1978) year the difference in yield between treatments was not statistically significant. In the unpruned (1979) and deep skiffed (1980) years pruning in cold weather and interplanting (T_3) gave the highest yield. However, in 1979 the yields from pruning in the cold weather and in the rains with interplanting (T_3 or T_5) were not significantly different.

5. SOIL CLIMATOLOGICAL SURVEY

A series of experiments were started in 1962 to study the growth of different kinds of tea under widely varying soil and climatic conditions and also their response to different levels of nitrogen.

Five clones viz. TV1, TV2, TV3, TV18 and 3/22 were tried at four levels of nitrogen at 0, 55, 110, and 165 kg N/ha.

The summarised results for fourteen years (i.e. 1967-80) of one of the expts. at Nyasyllee T.E. (D 24) are shown in Table 2.15.

Table 2.15. *Average yield (KMTH) of clones for the period 1967—80 under different levels of nitrogen application.*

N Dose	Clone	Yield KMTH				
	TV1	TV2	TV3	TV18	3/22	Mean
No	1340	916	850	1748	1056	1182
N_{55}	1929	1493	1463	2514	1665	1813
N_{110}	2134	1720	1636	3171	1876	2107
N_{165}	2314	1871	1608	3230	2189	2242
Mean	1929	1500	1389	2656	1696	

The expt. has been discontinued from 1980 and the yields for 1980 (MS year) are given in table 2.16.

Table 2.16. *Clone × Nitrogen interaction on 1980 yield.*

Clone	Yield KMTH					
Nitrogen kg/ha	TV1	TV2	TV3	TV18	3/22	Mean
N_0	1796	1040	940	2556	984	1463
N_{55}	2402	1729	1602	3051	1952	2147
N_{110}	2740	2081	1828	3731	2228	2522
N_{165}	2961	2194	1790	3699	2602	2649
Mean	2474	1761	1540	3259	1942	

C.D. (P=.05) Between Nitrogen doses = 226
" " Clones = 212
Clone × Nitrogen = NS
CV_1 % = 11.55
CV_2 % = 11.62

The data show that yields of the clones varied significantly, TV18 being the highest yielder. The order in terms of yield was TV18>TV1>3/22>TV2>TV3. However, the difference between clones TV2 and TV3 was found to be barely significant.

Response to N of all the clones increased progressively upto 110 kg N/ha beyond which, the trend become inconsistant.

Highlights

Effect of N-serve was not visible either on crop yield or response to nitrogen. Potash application produced significantly higher yield. Mulching with Guatemala *outyielded no mulch. Chemical weed control proved superior to cheeling.*

Oxyfluorfen, a new preemergence herbicide, has been found to be very effective in controlling annual broadleaf weeds and grasses in tea. The tank mix of paraquat and diuron at 0.4+1.0 kg/ha was found to be more effective on perennial grasses, Paspalum conjugatum *and* Axonopus compressus *than at 0.4+0.5 kg/ha. Glyphosate showed very good activity against ferns. The greater efficacy of solubilized glyphosate over normal glyphosate in controlling* Imperata cylindrica *was further confirmed.*

Nitrogen

A factorial experiment B 8/1 initiated in 1966 with three nitrogen levels (100, 200 and 300 kg/ha) on two clones (TV1 and TV9) planted at four different spacings (120 cm×90 cm, 120 cm×45 cm, 120 cm × 30 cm, and 120 cm × 22.5 cm. with 9,260, 18,520, 27,780 and 37,040 plants/ha respectively) was continued. A basal dose of 50 kg P_2O_5 and 100 kg K_2O per hectare was applied to all plots.

The results of the experiment for the years 1976 1980 are presented in table 3.01.

Table 3.01. *Effect of spacing, clone and nitrogen on yield of made tea (kg/ha).*

Treatments		1976 L.P.	1977 D.S.	1978 U.P.	1979 L.P.	1980 D.S.
Nitrogen (kg/ha)	100	1964	1682	1836	2022	1826
	200	1633	1308	1945	1827	1719
	300	1125	782	1417	1307	1020
C. D. at 5% level		184	178	218	1168	214
Spacing	120 × 22.5	1875	1519	1965	1930	1776
	120 × 30	1562	1293	1819	1756	1562
	120 × 45	1524	1180	1694	1671	1442
	120 × 90	1333	1037	1451	1518	1306
C.D. at 5% level		212	204	266	194	248
Clone	TV 9	1573	1478	1875	1570	1577
	TV 1	1575	1036	1590	1868	1466
C.D. at 5% level		N. S.	145	178	137	N. S.
C.V. %		16	19	17	13	19

The trend of higher yield with closer spacing continued although the difference in yield between the two very close spacings was gradually narrowing down.

Application of 100 kg nitrogen per hectare maintained the lead over 200 kg and 300 kg N/ha but the difference between 100 kg and 200 kg N/ha reduced considerably during the unpruned year, 200 kg N/ha yielding a little more than 100 kg N/ha although the TV9 tended to yield higher during deep skiff and unpruned years while TV1 performed better in the year of light prune. It is possible that this difference was due to considerable drop in yield of TV9 bushes during the year of L.P. when the wood at the pruning level become too thick.

None of the interactions were significant in any year except in 1977.

The experiment B104 was started in 1957 to study the effect of three levels of nitrogen (90, 135 and 180 kg/ha) on two *jats* (Betjan and Gaurishankar) of tea planted at five different spacings. In the initial stage the response to nitrogen levels was not significant except in 1961. The highest dose of nitrogen (180 kg/ha) produced significantly less yield from 1969 to 1980 than 90 and 135 kg doses, while 135 kg gave less yield than 90 kg (Table 3.02).

Table 3.02. *Effect of three levels of nitrogen on the yield of made tea (kg/ha).*

Nitrogen levels (kg/ha)	1974 M.S.	1975 M. P.	1976 U. P.	1977 L. P.	1978 D. S.	1979 U. P.	1980 L. P.
90	1361	596	1875	1289	1504	1432	1336
135	1343	540	1764	1234	1412	1333	1243
180	1251	481	1591	1133	1280	1210	1074
C.D. at 5% level	56	31	87	62	74	80	73
C.V. %	9.6	13.0	11.1	11.4	11.1	11.4	7.8

The factorial experiment B 5.1 was initiated in 1961 with four levels of nitrogen (0, 50, 100 and 150 kg/ha) and two levels each of phosphate (P_2O_5, 0 and 25 kg/ha) and potash (K_2O, 0 and 100 kg/ha) on Tingamira *jat* of tea under shaded and unshaded conditions. As the shade remained very uneven, the shade trees were removed in 1980. The results of the unshaded part only are summarised below (Table 3.03).

Table 3.03. *Effects of different levels of nitrogen on the yield of made tea (kg/ha).*

Nitrogen levels (kg/ka)	1976 U. P.	1977 D. S.	1978 L. P.	1979 D. S.	1980 U. P.
0	1353	993	919	845	794
50	2076	1372	1341	1272	1193
100	2091	1274	1143	1183	1234
150	1786	1001	760	872	974
C.D. at 5% level	145	95	89	96	97
C.V. %	11.2	10.5	12.0	13.0	13.0

Progressive increase in yield upto 100 kg/ha was obtained in 1980, beyond which it declined. The difference in yield between 50 and 100 kg nitrogen per hectare was not, however significant. During the initial years high nitrogen under no shade yielded more than the lower rates. As years passed, nitrogen at either 100 or 150 kg/ha failed to maintain the lead significantly confirming the earlier findings that shade can-

Table 3.04. *Effect of different levels of phosphate and potash on the yield of made tea (kg/ha).*

Phosphate (kg/ka)	1976 U. P.	1977 D. S.	1978 L. P.	1979 D. S.	1980 U. P
0	1811	1136	1035	1037	982
25	1842	1184	1046	1049	1116
C.D. at 5% level	N.S.	N.S.	N.S.	N.S.	69
Potash (kg/ha)					
0	1593	1020	894	893	860
100	2060	1300	1188	1193	1238
C.D. at 5% level	103	67	63	68	69
C.V. %	11.2	10.5	12.0	13.0	13.0

Potash application produced significantly higher yield in all years while the effect of phosphate become significant only in 1980.

The experiment T/10 to study the effect of nitrification inhibitor N-serve on yield on clonal tea (clone 33/52) is continuing since 1979.

The main plot treatments contained four levels of nitrogen (0, 100, 200 and 300 kg N/ha) and the three sub-plots had no N-serve, 1 per cent N-serve and 3 per cent N-serve.

Results for 1979 and 1980 show that all the three levels of nitrogen gave significantly higher yield than no nitrogen while the differences between 100 kg, 200 kg and 300 kg nitrogen were not significant in 1979. In 1980 the second unpruned year, 300 kg application per hectare significantly out yielded those from 100 and 200 kg. No effect of N-serve was observed on crop yield or response to nitrogen (Table 3.05).

Table 3.05. *Effect of nitrogen levels and N-serve on the yield of made tea (kg/ha).*

Nitrogen (kg/ha)level	1979 U. P.	1980 U. P.
0	2402	1649
100	2874	2099
200	2819	2146
300	2848	2448
C.D. at 5% level	155	234
C.V. %	4.9	9.7
0% N-serve	2717	2105
1% N-serve	2761	2144
3% N-serve	2730	2007
C.D. at 5% level	N. S.	N. S.
C.V. %	5.8	7.2

hosphate

The factorial experiment B105 was initiated in 960 on clone TV 2 to study the response of four levels f phosphate and four levels of potash (0, 45, 90 and 80 kg/ha) with a constant rate of 90 kg of nitrogen. 'he nitrogen rate of 90 kg/ha was increased to 135 kg om 1972. The results are presented in Table 3.06.

As reported earlier, positive response from phosiate application was observed in this experiment since 1974. While the beneficial effect of phosphate continued, there was no consistant difference amongst the various rates of phosphate in any of the years.

Table 3.06. *Effect of different levels of P and K on yield of made tea kg/ha.*

Treatments	1976 L. P.	1977 D. S.	1978 U. P.	1979 L. P.	1980 D. S.
P_0	1022	1348	1419	1211	1039
P_{45}	1231	1631	1657	1425	1418
P_{90}	1410	1646	1618	1480	1532
P_{180}	1446	1599	1591	1383	1533
C.D. at 5% level	139	175	165	178	196
K_0	1049	1218	1234	1053	1030
K_{45}	1293	1525	1585	1380	1382
K_{90}	1349	1687	1709	1486	1499
K_{180}	1420	1793	1808	1580	1609
C.D. at 5% level	139	175	165	178	196
C.V. %	15.3	15.8	14.6	18.2	19.9

Significant response to potash application was observed from the begining although there was no significant yield difference between the pairs of 45 and 90 kg K_2O/ha and also between 90 and 180 kg K_2O/ha levels. Application of 180 kg potash per hectare gave significantly higher yield over 45 kg in all the years except 1973 and 1976.

The experiment B23/3 is continuing since 1973 on shaded Tingamira *jat* of tea planted in 1961, to study

Table 3.07. *Effects of differerent levels of phosphate, mulch and weed control on yield of made tea (kg/ha)*

Treatments		1976 L. P.	1977 D. S.	1978 U. P.	1979 L. P.	1980 D. S.
Phosphate	0	1623	1890	1920	1428	1820
	50	1605	1843	1873	1448	1805
	100	1588	1852	1951	1473	1861
	150	1634	1901	1950	1414	1854
	200	1661	1907	1971	1478	1872
C.D. at 5% level		N. S.	N.S.	N. S.	N.S.	N. S.
C. V. %		6.76	12.66	8.31	12.40	12.32.
Mulch	No Mulch	1592	1800	1855	1408	1783
	Guatemala much	1652	1957	2011	1489	1902
C.D. at 5% level		56	63	77	46	85
C. V. %		7.58	7.45	8.89	7.07	10.29
Weed Control	Cheeling	1584	1823	1915	1424	1796
	Herbicide	1660	1934	1951	1472	1889
C.D. at 5% level		56	63	N.S.	46	85
C. V. %		7.58	7.45	8.89	7.07	10.29

whether the yield response to phosphate application is influenced by Guatemala mulch and manual and chemical control of weeds. The results are presented in table 3.07.

Phosphate application had no effect on yield. Mulching with Guatemala significantly out yielded the no mulch plots as did chemical weed control over cheeling. However no difference between chemical weed control and mulching was observed, indicating that control of weeds without disturbing the soil was a significant factor in increasing the yield of tea.

Potash

The significant effect of potash application can be seen from Tables 3.04 and 3.06. The N × K interaction was significant in all the years from 1972 in experiment B 5.1 on unshaded tea, where 100 kg K_2O/ha was applied with 0, 50, 100 and 150 kg nitrogen per hectare (Table 3.08). The significant effect of potash application was observed when 100 kg K_2O/ha applied at every level of nitrogen (50, 100 and 150 kg/ha) against no potash application. Application of 100 kg K_2O/ha with 50 and 100 kg N/ha was at par and both the levels gave significantly more yield than 150 kg N with 100 kg K_2O/ha. When nitrogen was omitted the beneficial role of potash was not discernible.

Table 3.08. *Nitrogen and potash interaction on yield of made tea (kg/ha).*

Kg/ka	1977(DS)		1978(LP)		1979(DS)		1980(UP)	
N \ K_2O	0	100	0	100	0	100	0	100
0	1334	952	982	856	872	817	742	846
50	1241	1502	1193	1489	1130	1414	1023	1363
100	1058	1490	900	1386	963	1402	1026	1443
150	747	1254	499	1020	606	1137	649	1299
C.D. at 5% level	135		126		136		137	
C.V. %	10.5		12.0		13.0		13.0	

Micronutirents

Two trials were conducted since 1978. The first trial T/2 was to study the response of different micronutrients and their combinations on the yield of Betajan *jat* of tea planted in 1957. The micronutrients were zinc, boron, magnesium, manganese and molybdenum alone and in various combinations.

The treatment effects were not significant in any year (1978, 1979, 1980).

The other trial T/3 was conducted to study the effect of different commercial formulations of micronutrients on yield of JTCL mixed clones planted in 1957. The treatment differences were not significant.

Irrigation

A single replication trial T/1 on drip irrigation was initiated in 1977 in a section of mixed clones planted in 1973. The treatments were: 1) Drip irrigation 2) Drip irrigation with dissolved fertiliser and 3) No irrigation. All treatments received 100 kg each of nitrogen and potash per hectare. In treatment 2 the fertilisers were applied through irrigation water while in treatments 1 and 3 these were applied broadcast. The yield increments from irrigation are shown in table 3.09.

Table 3.09. *Per cent yield increments over unirrigated control*

Treatments	1978 U. P.	1979 U. P.	1980 L. P.
Irrigation alone	14.6	43.7	7.4
Irrigation with fertilizer	14.8	25.8	4.5

Effect of irrigation varied from year to year which could possibly be atributed to quantum and distribution of rainfall in October-April period (Table 3.12). Application of fertilizer through irrigation water had no advantage over normal broadcast application. It is not clear however why the crop was depressed during 1979 and 1980 when irrigation was given with fertilizer.

A sprinkler irrigation trial T/9 was initiated in 1979 in shaded Khorijan *jat* of tea to determine the effect of irrigation. The results of the experiment and the details of irrigation treatments are presented in Tables 3.10 and 3.11 respectively.

Table 3.10. *Effect of sprinkler irrigation on the yield of made tea (kg/ha)*

Treatments	1979 U.P.		1980 U. P.	
	Yield	% increase over control	Yield	% increase over control
Control (no irrigation)	1518		1243	
Irrigation at 25% depletion in the root zone	1890	24.5	1284	3.3
Irrigation at 50% depletion in the root zone	1870	23.2	1265	1.8
Replenishment of water on the basis of open pan deficit (100% ET)	1872	23.3	1390	11.8
Irrigation at 5 cm/month from December to April	1868	23.1	1374	10.5
Irrigation on the basis of statistical findings *	1758*	15.8	1389	11.7

*Irrigation was started only from January. No water could be applied from November as was scheduled in the treatment.

Table 3.11. *Details of irrigation applied in different treatment*

Tr. No.	Irrigation period 1978–79	Irrigation period 1979–80	Amount of water(cm) 1978–79	Amount of water(cm) 1979–80	No. of Irrigation 1978–79	No. of Irrigation 1979–80
1.	—	—	—		—	—
2.	26.2.79 to 21.4.79	--	13.5		3	—
3.	27.1.79 to 23.4.79	—	45.0		5	—
4.	3.1.79 to 2.5.79	31.12.79	17.0	0.64	5	1
5.	21.12.78 to 4.4.79	13.12.79 to 11.4.80	25.0	25.00	5	5
6.	2.1.79 to 3.5.79	15.11.79 to 16.4.80	38.6	19.89	9	7

In 1979, the first year of the experiment, irrigation gave significantly higher yield over no irrigation but no significant difference between the irrigation treatments was observed.

The treatment differences were not significant in 1980. This could be due to variation in rainfall distribution in the cold weather/spring during these two years which would be evident from monthly rainfall distribution (Table 3.12). The 1980 season was preceded by a wet winter while 1979 crop was harvested after a droughty cold weather and early summer.

Table 3.12. *Monthly rainfall (mm) as recorded at Tocklai*

	October '77–April '78	October '78–April '79	October '79–April '80
October	181.3	39.0	193.2
November	19.5	73.0	44.0
December	18.7	0.0	22.3
January	4.7	6.5	30.8
February	12.7	0.7	25.0
March	62.4	13.1	86.2
April	43.1	72.8	260.8
Total	342.4	205.1	662.3

Plucking

An experiment on plucking standard B112.1/1 was initiated in 1976 on shaded Khorijan and Tingamira *jats* of tea planted in 1960. A comparative study of standard and black plucking throughout the season and in early, main and late season was the object of the experiment.

In 1976 and 1977 no significant difference amongst the treatments was observed. In 1978 and 1979, the light pruned and deep skiffed years, black plucking either throughout the year or during the main season significantly reduced crop when compared against black plucking either in early (BL-St-St) or late (St-St-Bl) season. In the unpruned year of 1980 although the trend remained similar, the yield differences were not significant (Table 3.13.)

The experiment T/11 has been continuing since 1979 on unshaded clonal tea (JTCL 35/52) planted in 1971 to study the effect of different methods of plucking. Results are presented in Table 3.14.

Table 3.13. *Effect of different combinations of standard (ST) and black (BL) plucking at different periods of the year on the yield of made tea (kg/ha).*

Plucking treatments at different periods			Yield at different plucking period											
			1978 LP				1979 DS				1980 UP			
Early	Main	Late	Early	Main	Late	Total	Early	Main	Late	Total	Early	Main	Late	Total
Bl	Bl	Bl	115	1189	464	1768	65	998	454	1517	531	1266	298	2095
Bl	Bl	St	102	1128	568	1798	65	985	540	1592	540	1213	348	2101
Bl	St	St	97	1402	495	1994	88	1169	499	1756	593	1359	275	2227
Bl	St	Bl	82	1381	443	1906	76	1118	458	1652	541	1396	269	2206
St	St	St	96	1302	472	1870	66	1149	510	1724	308	1401	322	2031
St	St	Bl	115	1406	449	1970	88	1247	477	1812	314	1339	273	1926
St	Bl	Bl	92	1133	449	1674	76	1018	476	1570	281	1209	318	1808
St	Bl	St	88	1175	504	1767	66	1019	500	1585	343	1151	387	1881
C.D. at 5% level						198				190				N.S.
C.V.%						6.1				6.6				9.9

Table 3.14. *Effects of different plucking methods on yield of made tea (kg/ha)*

Plucking methods		1979 U. P.	1980 U. P.
Pluck standard over janam throughout the year		2561	2247
-do-	+ raise a leaf in mid-April	2481	2190
-do-	+ raise a leaf in June/July	2323	1930
-do-	+ raise a leaf in November previous year	2448	2170
Pluck over one full leaf in beginning of the year and then pluck standard throughout the year		2521	2169
C.D. at 5% level		125	N.S.
C.V. %		3.3	6.2

Raising a leaf in June/July depressed yield in both the years, but the loss of yield was not significant in 1980.

The experiment T/5 has been continuing since 1978 on shaded clonal tea (JTCL 33/52) planted in 1967 to study the effect of black, standard and coarse plucking in conjunction with janam, fish leaf and step up plucking on yield.

Coarse plucking to janam and coarse plucking to janam + step up in July (no other time for step up was compared in this experiment) were significantly superior to all other treatments in 1978 and 1980, which were the deep skiffed and light pruned years respectively. In 1979, which was the unpruned year, only coarse plucking to janam was significantly superior to all other treatments (Table 3.15).

Long term yield trial on Tocklai clones

Results of a long term yield trial B40/1 of Tocklai released clones, Stock 450 and a *jat*, started in 1967, are given in Table 3.16.

The results upto 1979 were reported in the last annual report. In 1980, the unpruned year, TV17 outyielded all other clones except TV10 which happened also in the previous unpruned year i.e. 1977. This indicates an interaction between clone and type of prune/skiff.

Table 3.15. *Effect of standard and systems of plucking on yield (made tea kg/ha).*

Treatments	Janam			Fish Leaf			Janam + step up in July		
	1978 D. S.	1979 U.P.	1980 L.P.	1978 D. S.	1979 U. P.	1980 L. P.	1978 D. S.	1979 U. P.	1980 L. P.
Black plucking	1786	2723	1376	1885	2768	1625	1646	2417	1502
Leaving 1 + Bud	1997	2624	1549	1870	2766	1584	1820	2569	1493
Leaving 2 + Bud	2333	3212	1712	2063	2748	1523	2268	2865	1804

	1978	1979	1980
C. D. at 5% level between treatment	162	166	99
C. V. %	1.60	3.50	3.64

Table 3.16. *Yield of made tea of different clones (kg/ha).*

Clone	1977 U. P.	1978 L. P.	1979 D. S.	1980 U. P.
TV 1	1960	1791	1902	2140
TV 2	2009	1269	1325	1694
TV 4	2435	1850	2076	2181
TV 6	1740	1104	1240	1564
TV 7	2013	1471	1453	1490
TV 8	2440	1588	1718	2200
TV 9	2270	1907	1881	2059
TV 10	2947	1864	1857	2410
TV 11	2679	1983	1869	2327
TV 12	2654	1702	1835	1875
TV 13	2223	1365	1524	1923
TV 14	2703	2045	2074	2203
TV 15	2431	1656	1899	2342
TV 16	2410	2002	2078	2165
TV 17	3028	1892	2075	2723
TV 18	2716	1894	1940	2122
TV 19	2614	2262	2453	2246
107/2	2489	1892	2017	1985
Stock 450	2357	1759	1808	1960
Betjan	2296	1619	1681	1968
C.D. at 5% level	380	333	298	338
C.V. %	11.1	13.5	11.4	11.5

Plant spacing

In experiment B 8/2 started in 1966 on Khorijan *jat* of tea, the effect of spacing on yield and vigour was studied. The results are presented in Table 3.17.

Table 3.17. *Effect of different spacings on the yield of made tea (kg/ha).*

Spacing (cm)	Plant Population/ha	1976 L.P.	1977 D.S.	1978 U.P.	1979 L.P.	1980 D.S.
120×120	6944	1219	1385	1615	1161	1271
120×90	9259	1255	1484	1658	1218	1391
120×90 (double-ton)	18518	1380	1651	1759	1172	1459
120×75	11111	1208	1516	1774	1241	1433
120×75×75	13657	1547	1719	1868	1342	1529
120×60	13888	1437	1656	1812	1305	1492
C.D. at 5% level		186	133	153	79	106
C.V. %		9.2	5.6	5.8	4.2	4.9

In single hedge planting yield increased with the number of bushes per hectare; difference between the widest 120 × 120 cm and closest 120 × 60 cm spacings reached the level of significance every year. The difference in yield between 120 x 60 cm and 120 × 75 x 75 cm spacings, having almost equal number of bushes per hectare was very negligible, although the double hedge spacing had an edge over the single hedge. Planting of double-ton proved ineffective and in most cases the second plant was eliminated by competition.

WEED CONTROL

Weed Competition in Young Tea

A field experiment was initiated in April 1979 on an area planted with TV1 and TV18 in December 1978 to study the effect of weed competition on young tea. *Borreria hispida* accounted for 90% of weed infestation in the experimental area. Plots were *cheeled* and hand weeded once a month for periods of 2, 4, 6, 8, 10, and 12 months beginning April. Other plots had weed control for 4 months from June to September and from September to December.

Mortality was the highest when weed control started only in September. Weed free situation for only two months from April to May also resulted in higher mortality. Mortality of infilled plants was found to be higher with TV1 than with TV18.

The yield levels observed in treatments having 8 (April-November), 10 (April-January), and 12 (April-March) weed free months were at par (Table 3.18). The lowest yield was obtained from the plots kept weed free only for the 2 months of April and May and for 4 months from September to December.

Table 3.18. *Effect of weed control for different periods of the year on the yield of young tea (made tea kg/ha).*

Weed free period	No. of weed-free months	Yield TV 1	Yield TV 18
Apr — Mar	12	1115	1298
Apr — Jan	10	1101	1222
Apr — Nov	8	901	1096
Apr — Sep	6	733	976
Apr — Jul	4	501	562
Apr — May	2	133	190
Jun — Sep	4	498	568
Sep — Dec	4	119	142
LSD at 5% level		328	

New Herbicides

Search for more effective new herbicides continued this year also. Oxyfluorfen, Oxadiazon and metribuzin which were the more promising of the

preemergence herbicides in trials of 1979-80, were tested further. The results showed that oxyfluorfen is the most promising of the preemergence herbicides as it has greater persistence of activity compared to simazine and diuron presently used in tea (Table 3.19)

Another preemergence herbicide tested for the first time was NC 20484 of Fisons, U.K. Two experiments with different rates of application were conducted in two locations, one inside tea area and the other in non-cropped land. NC 20484 showed very little activity on broadleaf weeds in comparison with simazine and diuron. Its effect on grass weeds like *Paspalum conjugatum*, *Axonopus compressus*, etc. was encouraging but to obtain 80% control after 2 months, 3 kg a.i. of the herbicide is required per hectare.

Terbutryn (Igran), a new postemergence herbicide, has been tested for its efficacy against *Borreria hispida*, the predominant annual broadleaf weed. It showed only a partial effect compared to 2,4-D.

Table 3.19. *Effect of oxyfluorfen, metribuzin and oxadiazon for preemergence control of mixed weeds.*

Herbicide	Rate (kg a.i./ha)	% weed control after 1 month	2 months	4 months
Oxyfluorfen	0.25	96	63	53
	0.50	98	73	75
	1.00	100	90	80
Metribuzin	0.5	83	63	35
	1.0	88	56	40
	2.0	95	75	50
Oxadiazon	0.5	80	58	32
	1.0	93	68	44
	2.0	98	80	63
Simazine	1.0	91	70	35
	2.0	93	78	50
Diuron	1.0	95	81	48
	2.0	96	95	65

CONTROL OF INDIVIDUAL WEEDS

Axonopus compressus

A field experiment was conducted on a pure stand of *Axonopus compressus* grown in the weed nursery to compare the efficacy of paraquat-diuron, paraquat-MSMA, and dalapon-MSMA combinations with glyphosate.

Table 3.20. *Effect of paraquat-diuron and paraquat-MSMA on the control of Axonopus compressus*

Herbicide treatment	Rate (kg a.i./ka)	% control of *Axonopus compressus* after 6	20	40 days
Paraquat	0.4	80	38	13
Diuron	0.5	5	21	8
	1.0	10	26	13
Paraquat + diuron	0.4+0.5	88	76	62
Paraquat + diuron	0.4+1.0	93	88	93
MSMA	1.0	36	51	43
Paraquat + MSMA	0.4+0.5	86	66	32
Paraquat + MSMA	0.4+1.0	96	83	80
Glyphosate	0.8	11	68	90
Dalapon + MSMA	3.0+1.0	78	91	100

Paraquat-diuron (0.4+1.0 kg a.i./ha) and dalapon-MSMA combinations showed better effiect than paraquat-MSMA combinations and their effects were comparable with that of glyphosate applied at 0.8 kg a.i./ha (Table 3.20).

2. Paspalum conjugatum

A field trial was conducted to determine the effect of paraquat-diuron and paraquat-MSMA combinations on the control of *Paspalum conjugatum*, the most predominant perennial grass in tea. The experiment was laid out on a pure stand of *P. conjugatum* grown in weed nurseries.

The results indicated that 0.4 kg a.i./ha paraquat when mixed with 1.0 kg a.i./ha diuron was more effective than with 0.5 kg a.i. /ha diuron (Table 3.21). This effect was comparable to that of paraquat-MSMA combination. Glyphosate (0.8 kg a.i./ha), however, gave more effective control of *P. conjugatum* than any of the other treatments.

Table 3.21. *Effect of paraquat-diuron and paraquat-MSMA combinations in the control of Paspalum conjugatum*

Herbicide treatment	Rate (kg a.i./ka)	% control of *Paspalum conjugatum* after 3	7	14	21	40	65 days
Paraquat	0.4	85	78	46	33	15	11
MSMA	1.0	23	40	65	46	35	31
Paraquat + MSMA	0.4+0.5	81	75	55	45	36	8
Paraquat + MSMA	0.4+1.0	90	85	71	71	68	40
Diuron	0.5	7	8	35	26	26	6
Diuron	1.0	5	21	63	53	51	25
Paraquat + diuron	0.4+0.5	80	80	63	60	55	28
Paraquat + diuron	0.4+1.0	83	83	76	70	68	45
Glyphosate	0.8	5	16	58	83	81	85

3. Panicum hamidorum

Two field trials were conducted in weed nurseries on a pure stand of *Panicum hamidorum*, a perennial grass, to determine the effect of different herbicides and herbicide combinations on its control.

Paraquat and MSMA, applied alone or in combination, showed very little effect on the final control

Table 3.22. *Effect of paraquat and glyphosate on the control of Panicum hamidorum*

Herbicides	Rate (kg a.i./ka)	% control of *P. hamidorum* after 10	30	60 days
Paraqiat	0.4	78	15	8
MSMA	1.0	58	31	13
Paraquat + MSMA	0.4+1.0	83	33	13
Glyphosate	0.4	23	60	31
Glyphosate	0.8	35	85	78
2,4-D	0.8	0	5	0
Glyphosate+ 2,4-D	0.4+0.8	10	30	5
Glyphosate+ 2,4-D	0.8+0.8	15	31	12

of this grass weed (Table 3.22). Glyphosate at 0.8 kg a.i./ha controlled 78% of the infestation, but its activity was drastically reduced when mixed with 2,4-D.

4. Ferns

In an experiment conducted on a pure stand of ferns (*Pteridium* spp.), Glyphosate was found to control them satisfactory at 0.8 kg a.i./ha (2 L Roundup). Asulam, another postemergence herbicide, which failed to control ferns in earlier years showed that it has a delayed effect. Although asulam showed very little effect upto one month after application, it controlled 90% of the infestation by ferns after two and half months (Table 3.23). At 0.4 kg a.i./ha solubilized glyphosate continued to show greater effect on ferns compared to the commercial formulation.

Table 3.23. *Effect of glyphosate, solubilized glyphosate, and asulam on the control of ferns.*

Herbicide	Rate (kg a.i./ka)	% control of Ferms after 14	35	50	65	80	95 days
Glyphosate	0.4	41	60	65	68	68	70
Glyphosate	0.8	68	83	88	93	92	93
Asulam	0.8	5	8	8	40	50	57
Asulam	1.2	5	18	25	50	57	67
Asulam	1.6	5	21	23	53	70	77
Asulam	2.0	5	20	25	53	80	90
Solubilized glyphosate	0.4	56	76	83	93	87	92

HERBICIDE ACTIVITY

Solubilization of glyphosate

Experiments conducted in the past two years showed that the activity of the commercial formulation of glyphosate could be enhanced markedly by solubilizing and applying it in the solubilized form. This year large-scale field experiments were conducted to further study the effect of solubilized glyphosate on *Imperata cylindrica*.

The results confirmed the earlier finding of greater effect of solubilized glyphosate at equal rates. At 0.4 kg a.i./ha, solubilized glyphosate showed almost the same effect as shown by glyphosate at 0.8 kg a.i./ha.

In separate experiments, its peformance on other perennial grasses like *Paspalum conjugatum* and *Axonopus compressus* was evaluated. The data further confirmed that at equal rates, solubilized glyphosate is more effective than glyphosate.

Two other experiments were conducted to test the suitability of glycerol monooleate produced in India against that produced in U.K. as an ingredient of making solubilized glyphosate. The tests showed the Indian product to be as good as the British product.

Herbicide Toxicity

Phytoxicity of preemergences, oxyfluorfen, metribuzin, fluchloralin, simazine, diuron and some of their combinations were tested for their phytoxicity on 18 months old TV18 plants. Diuron caused considerable damage to tea bushes followed by metribuzin, both at 2 kg a.i./ha. In case of metribuzin, 33% damage shown after 3 weeks of application gradually reduced to about 5%, after two months. In the case of diuron, 63% damage observed after 3 weeks came down to 18% after two months. Oxyfluorfen showed no toxicity symptoms at 1 kg a.i./ha (4 L/ha Goal), but in the initial stage at 2 kg a.i./ha (8 L/ha Goal) it caused mild toxicity in the first 3 weeks, which soon disappeared.

Combination of diuron with oxadiazon or fluchloralin damaged tea bushes to about 5%, whereas fluchloralin and oxadiazon alone did not have any toxic effect. Simazine had very little toxic effect. In a separate experiment oxyfluorfen was applied as a directed spray only on the weeds, scrupulosly avoiding spray drift to bushes, as a non-directed spray and also on top of tea bushes. The results showed that spraying on top of bushes at 1 kg a.i./ha (4 L/ha Goal) caused moderate toxicity from which the plants finally recovered. There was, however, no mortality. Nondirected spray, allowing spray drift on to tea bushes caused no damage.

Soils and Meteorology

Highlights

Nitrification inhibitors and slow release nitrogenous fertilisers increased nitrogen use efficiency of young 2-3 years old, pot grown tea plants to 40-50 per cent and promoted residual build up of soil nitrogen, together accounting for 60-80 per cent of the applied nitrogen. Nitrate Reductase Activity of actively expanding young leaves increased with the level of nitrogen application, either in the ammonical or nitrate form. The increase was more pronounced in reduced than in full sunlight. The available phosphate fraction in soil increased with the level of phosphate application either in soluble or insoluble form. However, moisture and organic matter influenced phosphate availability of soils. Pyrites was as good as aluminium sulphate in correcting acidity of sub-acid soils. Manganese increased uptake of nitrogen by young tea plants as well as availability of soil phosphorus.

For designing drainage systems in the Dooars, rainfall input of 163 mm/day would be a reasonal estimate which is based on a 5—year return period. Water table depth and ground water removal rate should be considered together for diagnosing waterlogging problems. Control of water table at 90 cm in especially designed tanks resulted in optimum moisture and temperature conditions than under conditions of waterlogging. Further lowering of the water table did not confer additional benefit on the growth of plants. For lowering of the water table to the desired depth within 24-48 hours of a peak storm in a particular water shed and soil type, the diameter of pipes as well as their spacing should be properly choosen.

Studies on coated and slow release nitrogenous fertilisers

The effects of application of nitrogen in the form of coated nitrogenous fertiliser, slow acting organic nitrogenous fertiliser and a combination of fertiliser nitrogen with nitrification inhibitors on the leaching losses and uptake of nitrogen by young tea in a pot culture experiment were reported last year (Ann. Rep., 1979-80, p. 25-27). In the same experiment residual build up of soil nitrogen, if any, was also investigated. Data are given in Table 4.01.

Table 4.01. *Residual build up of soil nitrogen as affected by coated and slow acting nitrogenous fertilisers and nitrification inhibitors.*

Nitrogenous fertiliser	Residual nitrogen in soil as mg N per pot				Soil nitrogen build up as percentage of applied nitrogen				
	T_2	T_3	T_4	T_5	T_3	T_3	T_4	T_5	Average %
Sulphur coated urea	80	197	320	480	44	54	59	66	56
Lac coated urea	7	36	158	160	4	10	29	22	16
Neem coated urea	36	87	175	306	20	24	32	42	30
Isobutylide ne di-urea	36	164	197	233	20	45	36	32	33
Urea + 1.0% N-Serve	62	149	219	328	34	41	40	45	40
Urea + 1.0% A.M.	58	124	224	364	32	34	41	50	39

T_2 = 50 kg N/ha = 182 mg N/pot.
T_3 = 100 kg N/ha = 364 ,, ,,
T_4 = 150 kg N/ha = 546 ,, ,,
T_5 = 200 kg N/ha = 728 ,, ,,

Isobutylidene diurea is slow acting organic nitrogen.

The residual nitrogen content of soil increased progressively with the increasing rates of application of nitrogen and this is true for the various forms of slow acting nitrogenous fertilisers and inhibitors included in this experiment. Considering all the four rates of application, nitrogen build up in soil as percentage of the applied nitrogen varied between 20 and 66 per cent (with the exception of lac coated urea.) An average of 56 per cent of the applied nitrogen was added to soil by sulphur coated urea, 40 per cent by the use of inhibitors like N-serve and A.M. and about 30 per cent by either neem coated urea or isobutylidene diurea.

The balance sheet of different forms of applied nitrogen is shown in Table 4.02.

Table 4.02. *Balance sheet of different forms of applied nitrogen (average of four N levels).*

Nitrogenous fertiliser form (1)	% N recovered by plant (2)	% residual build up of soil N (3)	% N lost by leaching (4)	% N lost by volatilisation/denitrification (5)	% nitrogen retained by soil and plant (2+3) (6)
Sulphur coated urea	22	56	12	0	78
Lac coated urea	21	16	58	5	37
Neem coated urea	32	30	36	3	62
Isobutylidene diurea	46	33	19	4	79
Urea + N- serve	44	40	11	5	84
Urea + A. M.	43	39	11	7	82

The nitrogen use efficiency over one year period by fifteen month old clonal (TV1) plant varied between 20 to 46 per cent. The losses due to leaching and volatilisation/denitrification varied between 16 to 39 per cent (sum of columns 4 and 5), with the exception of lac coated urea. In these pot studies for two years, the losses of applied nitrogen have been drastically brought down to a level of about 20 per cent with the use of

nitrogen in combination with inhibitors or in the form of either sulphur coated urea or isobutylidene diurea. Neem coated urea also significantly reduced the losses due to volatilisation and leaching from 50-60 per cent to 40 per cent. It has also been observed that substantial quantities of applied nitrogen from slow acting forms/inhibitors remained as residues in the soil (with the exception of lac coated urea) which could be potentially available for the growth of the plant. Both plant uptake and soil residue (column 6), accounted for about 80% of the nitrogenous fertilisers when applied as sulphur coated urea, isobutylidene diurea and urea with inhibitors, which was only 60% in the case of neem coated urea.

However, the results for two years of pot experiment suggest that sulphur coated urea and lac coated urea do not seem to have promise for tea because of their low nitrogen use efficiency (column 2). Further, lac coated urea resulted in large leaching losses of nitrogen (column 4). The nitrogen use efficiency works out to about 40% (column 1) in the case of the last three fertilisers and provided the residual soil nitrogen is sustained these fertiliser forms/combinations are likely to prove efficient for tea. The use of inhibitors merit special consideration in view of the small quantity requied, (1 per cent by weight of urea) for achieving maximum nitrogen use efficiency by tea, very substantial residual build up of soil nitrogen and remarkably small losses of applied nitrogen. Although neem coated urea was found to be only half as efficient as inhibitors for arresting losses, yet this form showed higher nitrogen use efficiency by young tea as compared to the other coated fertilisers and, as such, can be considered for further trials, since it costs less than the inhibitors. Further trials are continuing in this direction.

Field trial using N-serve

The effect of nitrogen levels on the total nitrogen content of top soil and plucked shoot was found to be significant (Table 4.03). Third leaf samples were not sufficiently available throughout for carrying out nitrogen analysis.

Table 4.03. *Effect of nitrogen levels on the total nitrogen content of top (0–15 cm) soil and plucked shoots.*

Dose of nitrogen kg/ka	Percent nitrogen content (on dry wt) of top soil and plucked shoot							
	June		August		October		Mean of months	
	Soil	Shoot	Soil	Shoot	Soil	Shoot	Soil	Shoot
0	0.080	3.50	0.081	3.98	0.078	3.94	0.080	3.81
100	0.087	3.84	0.088	4.10	0.082	4.12	0.086	4.02
200	0.092	4.05	0.091	4.24	0.085	4.13	0.089	4.14
300	0.087	4.09	0.090	4.21	0.086	4.15	0.088	4.15

C.D. for N dose in soil = 0.002
C.D. for „ in shoot = 0.12
C.D. for month × N dose : for soil = 0.002;
for shoot = 0.16

Both top soil and shoot nitrogen content increased progressively with increasing levels of fertiliser application upto 200 kg/ha level, beyond which there was no increase.

A highly significant positive correlation was observed between nitrogen in top soil and plucked shoot (r=0.85). Nitrogen contents of top soil and shoot were also significantly affected by season. As the season progressed soil nitrogen generally decreased whereas the reverse trend was observed in case of shoots. The interaction between N levels and season on the nitrogen contents of both soil and leaf was also found to be significant.

Soluble nitrogen was analysed in the mature leaf just above the plucking table, bud plus first leaf, and second leaf of plucked shoots collected from each of the twelve treatments of the experiment. Second leaf showed the maximum concentration of soluble nitrogen (Ammonia + nitrate) and 1% N-serve treatment tended to increase the soluble nitrogen content of both bud plus first leaf and second leaf, specially the latter, upto 200 kg of applied nitrogen per hectare. Second leaf samples from individual plots of all treatments are now being analysed again as a follow up of this interesting observation.

Table 4.04. *Influence of N-serve and nitrogen levels on the soluble nitrogen content (ppm).*

	0 kg/ha N			100 kg/ha N			200 kg/ha N			300 kg/ha N		
	0	1%	3%	0	1%	3%	0	1%	3%	0	1%	3% N-Serve
Mature leaf just over plucking table	150	144	169	160	140	160	184	159	164	150	184	244
Bud plus first leaf	190	228	237	209	228	190	248	247	229	267	276	248
Second leaf	233	307	263	336	409	321	335	409	365	336	307	307

Nitrate reductase activity

For getting an insight into the question of nitrogen use efficiency by tea, attempts were made to find out whether nitrate reductase activity is influenced by levels and forms of nitrogen, clonal differences and environmental factors like light intensity. Work carried out on the methodology and the influence of genetical differences on the nitrate reductase activity has already been reported (Ann. Sci. Rep., 1977-78, p. 27).

Nitrate reductase activity of first leaf from a pot experiment was determined on four occasions during the year. The pot experiment comprised of young tea grown under full light and 50 per cent light intensity under bamboo lath frame and receiving nitrogen at levels of 0, 50, 100, 150 and 200 kg/ha in the forms of nitrate (potassium nitrate) and ammonia (ammonium sulphate). Results are graphically shown in Fig. 4.01.

It is seen that nitrate reductase activity remarkably increased under reduced light intensity as compared to full light and this was true for both the forms of nitrogen at all levels of application. Ammonium sulphate induced higher nitrate reductase activity than potassium nitrate. However, the differences between the forms of nitrogen were more prominently exhibited under full light intensity than under reduced light. Nitrate reductase activity increased significantly with increasing levels of nitrogen application, upto 200 kg/ha nitrogen with ammonium sulphate and upto 150 kg/ha nitrogen with potassium nitrate.

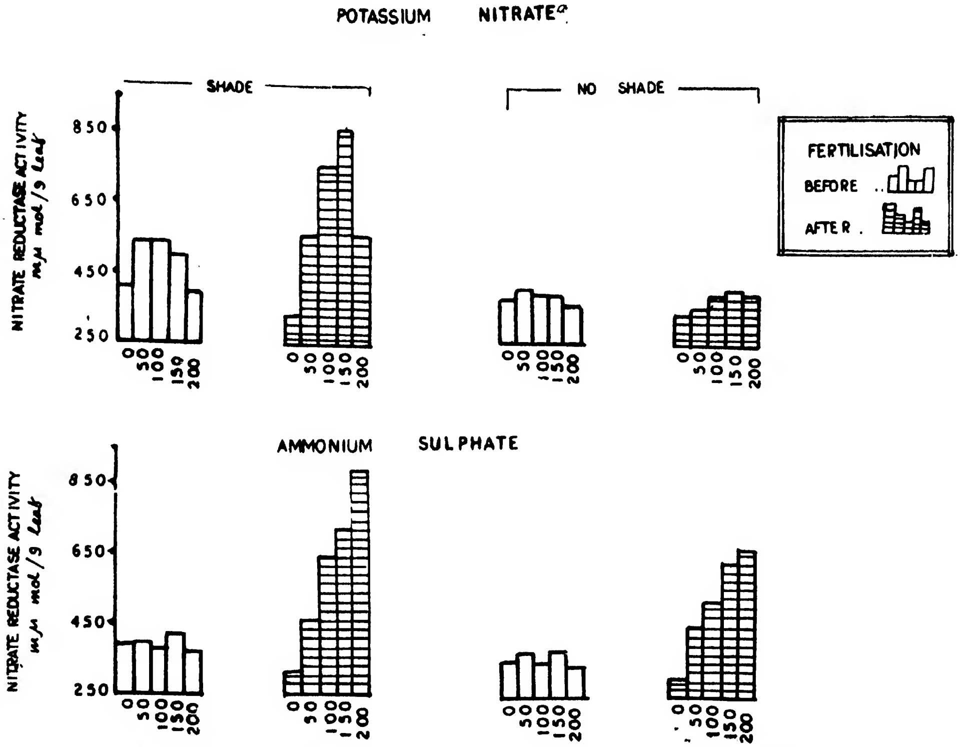


Fig 4·01. Influence of Shade form and level of Fertiliser on Nitrate reductase activity.

Studies on nitrogen metabolism

Standardisation of nitrate estimation in tea shoots has been completed by modifying the standard colorimetric procedure to take care of polyphenol interferance. The modified method is rapid and reproducible and has now been used for rapid tissue test of nitrate nitrogen in plucked shoots from long-term fertiliser trials. Results so far obtained showed high accumulation of nitrate nitrogen in pluckable shoots (600—1,000 p.p.m.), and higher content in the top soil layers (10-20 p.p.m.). Shoot and soil samples are now being analysed monthly to find out whether any correlation exists between total and nitrate nitrogen contents of shoots and soils under different rates of nitrogen application.

Presence of nitrite nitrogen (NO_2—N) could not, however, be traced in tea shoot samples.

Studies on phosphate availability

Phosphate availability in soil and phosphate uptake from soluble phosphate fertiliser (superphosphate)

and insoluble phosphate fertiliser (dicalcium phosphate) were investigated in a pot trial under glasshouse conditions. The phosphate levels were 0, 120, 240 and 360 kg P_2O_5/ha. Phosphate availability in terms of water soluble phosphate, Bray I and Bray II phosphates were determined 2, 3, 5, 6 and 8 months after application of fertilisers (Table 4.05).

Table 4.05. *Release of water soluble, Bray I and Bray II available phosphates as influenced by forms and levels of application of phosphate (mean data of different sampling occasions).*

Phosphate fertiliser form	Phosphate levels kg/ha	p.p.m. available phosphate fractions in soil: Water soluble	Bray I	Bray II
Superphosphate	0	21	119	232
	120	32	145	273
	240	36	179	290
	360	46	209	330
Dicalcium phosphate	0	22	120	230
	120	32	158	250
	240	36	179	276
	360	44	208	298

C.D. at 0.1%, for form = 0.98, for level = 24.46, for F×L = 78.67 (for Bray I and Bray II P).
C.D. at 5%, for form = 0.96, for level = 4.0, for form × level = 13.11 (for water soluble P).

All the three fractions in soil increased significantly with increasing levels of phosphate application throughout the period of sampling and this was true for both forms of phosphate. No significant difference in available phosphate fractions was observed between the P-fertilisers until the last sampling after eight months from application. While a declining trend of Bray I and Bray II phosphate fractions was observed at the end of six months, no such trend was noticeable in the case of water soluble phosphate fraction. The Bray II potentially available fraction was always higher than the Bray I readily available fraction. Uptake measurements will be carried out after harvesting the plants during 1981.

Influence of depth of placement on phosphate release and uptake by young tea :

A pot experiment with young tea, which received superphosphate (SP), rock phosphate (RP) and half super + half rock phosphate ($\frac{1}{2}$ SP + $\frac{1}{2}$ RP), each at three different levels (0, 90 and 180 kg P_2O_5/ha) and at three different depths (5, 10, and 20 cm), was conducted during the year. Both Bray I and Bray II available P fractions in soil were estimated after 3, 5 and 7 months from the time of fertiliser application. Phosphate uptake by young tea plants will be estimated after harvesting the plants. Results of Bray I and II available phosphate fractions are given in Table 4.06.

Irrespective of the forms of fertiliser, soil available phosphate fractions (Bray I and II) increased significantly with increasing levels of phosphate. The effect of depth of placement on the available phosphate fractions was not found to be significant. As in Table 4.05, the Bray II available P-fraction was much higher than the Bray I fraction with different forms and levels of phosphate. Phosphate application, as a combination of $\frac{1}{2}$ super plus $\frac{1}{2}$ rock at the rate of 180 kg P_2O_5/ha resulted in highest amount of Bray I and II available phosphate fractions and this was true for all the three depths of placement.

Table 4.06. *Release of Bray I and Bray II available P fractions as influenced by depth of placement and forms of P-fertilisers, (mean of three sampling occasions).*

Phosphate fertiliser form	Phosphate levels kg/ha	p.p.m. available phosphate fraction in soil: Bray I *5 cm	Bray I *10 cm	Bray I *20 cm	Bray II *5 cm	Bray II *10 cm	Bray II *20cm
Superphosphate	0	54	52	50	77	73	79
	90	98	87	92	134	112	124
	180	118	106	114	165	168	141
Rock phosphate	0	54	52	50	77	73	79
	90	78	71	107	137	136	157
	180	97	86	105	144	177	221
Half Super Phosphate + half rock phosphate	0	54	52	50	77	73	79
	90	85	87	98	139	120	140
	180	124	138	127	183	207	193

C.D. at 0.1% for form = 1.39, for level = 142.98, for F × L = 50.91
(*depth of placement)

Influence of moisture and organic matter on availability of soil phosphate

In a laboratory incubation experiment, the influence of organic matter and moisture on phosphate availability from two different phosphate sources, viz. superphosphate (soluble) and dicalcium phosphate (insoluble) was studied at fortnightly intervals. The experiment included three levels of phosphate application (0,90 and 180 kg P_2O_5/ha), two moisture levels (field capacity and half field capacity) and three tevels of startch as organic matter (0, 2.5 and 5.0 g/kg soil). Data from fortnightly analysis of samples over a five month period are shown graphically in Figs. 4.02 and 4.03.

Fig. 4.02 shows that both Bray I and Bray II soil available phosphate fractions increased remarkably under

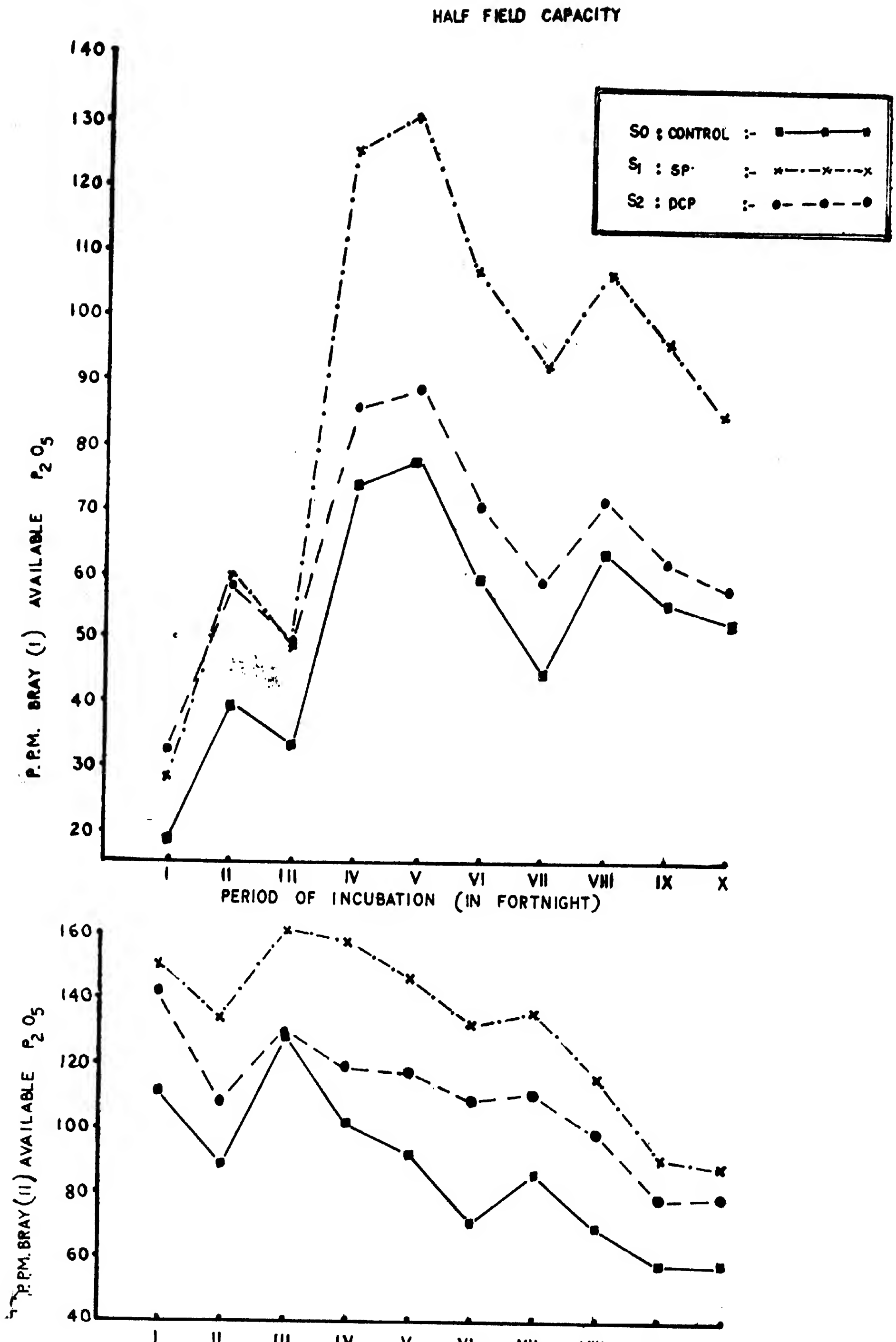
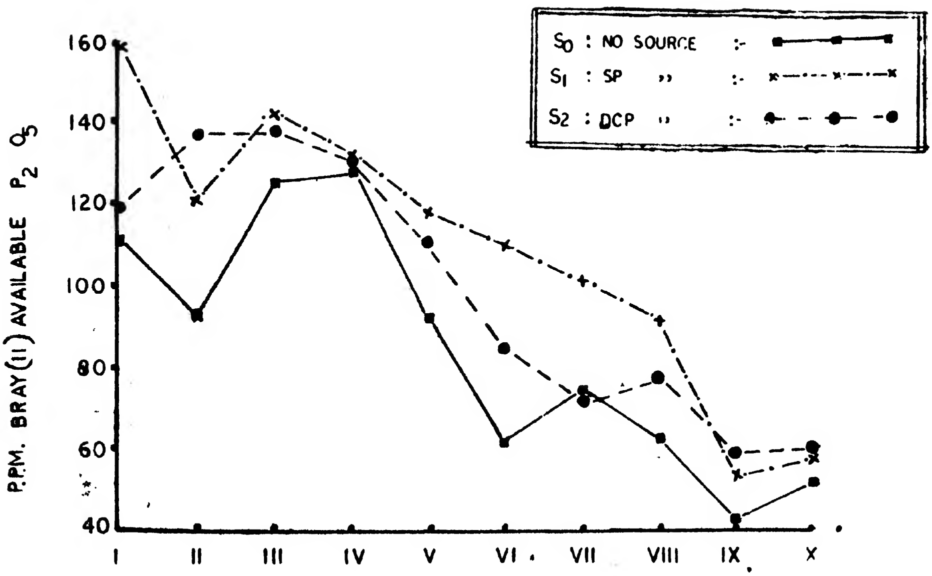


Fig 4·02. (a) Influence of soil moisture at field capacity on phosphate availability from different sources and levels of applied phosphate.



FIELD CAPACITY

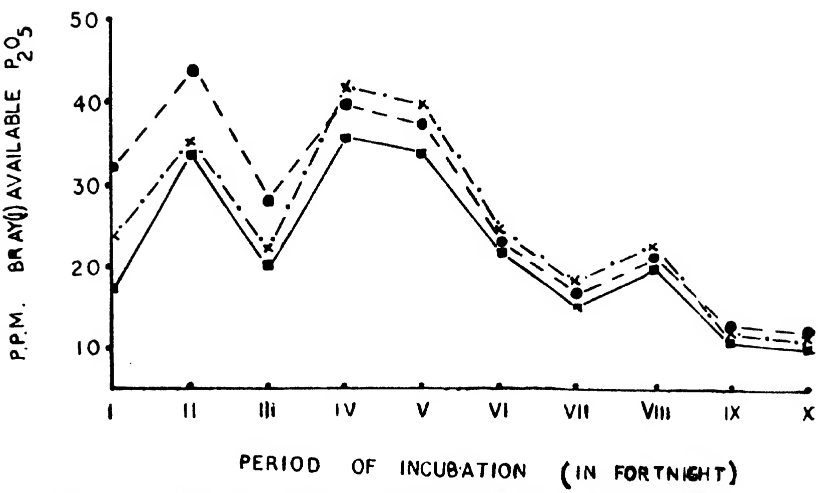


Fig 4.02. (b) Influence of soil moisture at half field capacity on phosphate availability from different sources and levels of applied phosphate.

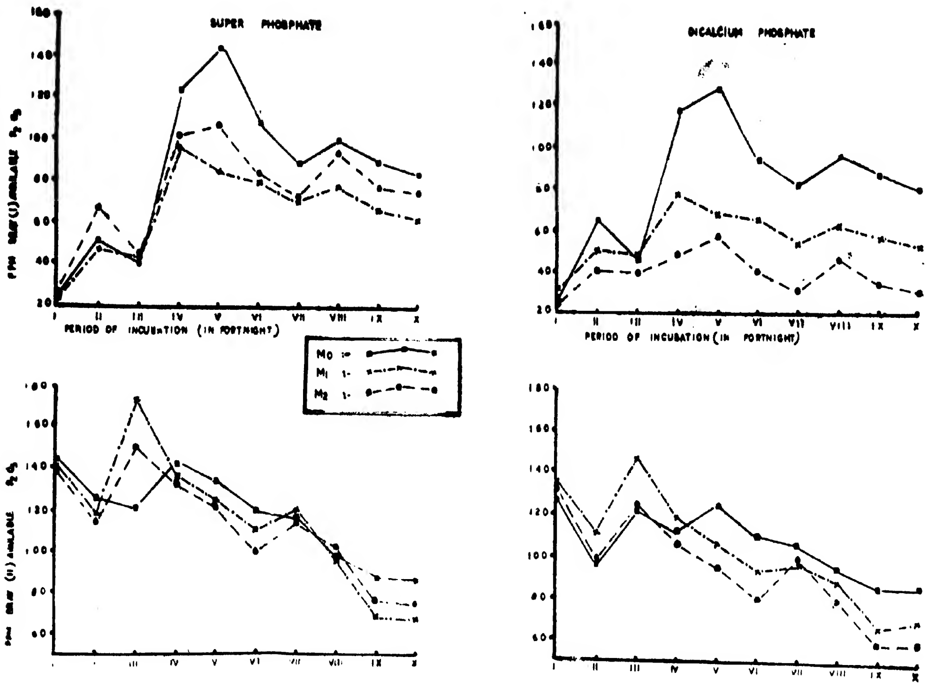


Fig 4·03. Influence of organic matter on phosphate availability from various sources and levels of applied phosphate

half field capacity moisture regime as compared to the field capacity. The influence of soil moisture status on phosphate availability was, however, more pronounced on the Bray I fraction than on Bray II, which was true both for unmanured soils and manured soils with different forms and levels of phosphate.

Fig. 4.03 shows that with prolonged incubation both Bray I and Bray II soil available phosphate fractions generally decreased with increasing quantity of organic matter application.

This was observed both at field capacity and at half field capacity, irrespective of the levels and forms of phosphate applied. However, the negative effect of organic matter on phosphate availability was more pronounced under half field capacity moisture regime in the presence of applied phosphate and after about two months incubation period. Similar conclusion was reported earlier (c.f. Ann. Sci. Rep., 1979-80, p. 29), except that the initial (7-14 days) transient increase of available phosphate with increasing quantity of organic matter was not confirmed by the present investigation. The negative influence of organic matter was more on the Bray I than Bray II fraction and this depressive effect was observed even after five months of incubation of the fertilised soils. The experiment confirms proximate immobilisation of soil phosphorus by organic matter, possibly via accelerated microbial activity.

Influence of soil factors like pH and texture on potassium availability

A laboratory incubation experiment on potash availability was carried out with three soils belonging to different textural classes, viz., loamy sand, sandy loam and silty clay loam. The pH of each soil was adjusted to 5.0, 5.5, 6.0 and 6.5, using dilute acetic acid and calcium carbonate. The pH levels were purposely selected in the borderline range for growth of tea in order to find out whether potassium availability increases or reduces at such a pH range. After equilibraiting for a period of two months, potassium was added @ 0, 50, 100, 150 and 200 kg K_2O/ha as muriate of potash. The pots were incubated for five months maintaining moisture at field capacity. Water soluble and exchangeable potassium were determined at the end of 1, 2, 4 and 5 months (Table 4.07).

Both water soluble and changeable potash content increased with increasing levels of potassium application. However, the effect of fertiliser potassium on the water soluble fraction was more pronounced in lighter soils (loamy sand and sandy loam) than in heavy soil at all the four levels of acidity.

Table 4.07. *Influence of pH and soil texture on the release of potassium from applied fertiliser (mean of four incubation periods as p.p.m. K_2O).*

K_2O kg/ha	Soil potassium category	Loamy sand				Sandy loam				Silty caay loam			
		5.0	5.5	6.0	6.5	5.0	5.5	6.0	6.5	5.0	5.5	6.0	6.5
0	Water sol.	18	16	18	14	16	11	16	14	26	19	19	27
	Exchangeable	29	60	67	44	24	20	22	29	70	92	65	63
50	Water sol.	41	28	24	22	38	20	25	24	32	26	38	40
	Exchangeable	43	88	105	67	37	49	42	56	75	110	100	72
100	Water sol.	63	47	41	44	81	42	38	52	45	31	36	45
	Exchangeable	85	200	142	90	70	72	82	86	94	123	105	95
150	Water sol.	98	76	51	52	125	54	58	53	48	39	41	59
	Exchangeable	121	161	141	117	106	92	85	113	129	128	119	130
200	Water sol.	124	112	69	69	190	78	80	71	59	44	42	57
	Exchangeable	90	246	157	148	130	109	127	133	124	138	159	134

Water soluble potassium decreased as the pH increased from 5.0 to 6.0 in loamy sand and from 5.0 to 5.5 only in sandy loam soil above which there was not much change. Change of pH did not affect water soluble potassium of the heavy soil.

Neither soil texture nor pH had a marked consistent effect on the exchangeable potash content. Both water soluble and exchangeable potash contents reached peak values within sixty days from the application of fertiliser, followed by a steady decline with increasing period of incubation reaching equilibrium after five months and this was true for all the three soils.

Available potash content in Darjeeling soils

Effect of season and levels of potash fertiliser application on soil available potash content were studied for a period of three years (1978-80) in a long-term NPK fertiliser trial in Darjeeling. Results confirmed that the seasonal trends of soil available potash content in Darjeeling are almost similar to those observed in Assam and the Dooars. There was a steady increase in available potash content during the dry season from December to April/May and a sharp decline during wet months from July/August to October/November. The change of soil available potash with manuring whether applied in March or July, was found to be rapid, reaching peak values within one month from the time of fertiliser application. This was true for all levels of potash application. These observations show that soil sampling for available potash should be done either during the dry period (December to February/March) or wet period (July to September/October), and that the same sampling time should be followed year after year. However, for practical reasons, it is recommended that potash sampling should be done during dry winter months.

Reclamation of sub-acid land

(i) A pot trial was carried out at Nagrakata for evaluating the comparative efficiency of three chemicals for reducing the pH content of sub-acid soil. The chemicals used were aluminium sulphate, ferrous sulphate (pyrites) and calcium sulphate (gypsum) at rates 5 and 10 t/ha each on a soil at pH 6.8. The soil was taken from Jaybirpara T.E., and after mixing with chemicals, the treated soils were intensively leached under laboratory conditions. Resutls are given in Table 4.08.

ble 4.08. *Effect of three different chemicals in reducing soil acidity.*

Chemical	Rate of application, t/ha	pH content of soil after months of application					
		1	2	3	4	5	6
Nil (Control)	0	6.80	6.75	6.70	6.80	6.70	6.80
Aluminium sulphate	5	4.25	4.25	4.60	4.50	4.45	4.45
	10	3.50	3.60	4.05	4.10	4.05	4.05
Pyrites	5	5.55	4.95	5.00	4.85	4.70	4.65
	10	5.05	4.85	4.30	4.05	3.85	3.85
Gypsum	5	6.50	6.50	6.60	6.70	6.40	6.50
	10	5.45	5.35	5.45	5.25	5.15	5.20

Aluminium sulphate was the most quick acting chemical but its effect stabilised only after five to six months. Pyrites took almost the same time in stabilising. There was practically no difference in effect between aluminium sulphate and pyrites at 10 t/ha rate, although aluminium sulphate was relatively more effective than pyrites at 5 t/ha. Gypsum was not found to be as effective as either aluminium sulphate or pyrites.

(ii) A field trial was also laid out at Dalmore T.E. (Dooars) in 1980 to find out the changes in soil pH with application of acid forming chemicals at various rates. Changes in pH are shown in Table 4.09.

There was hardly any change in acidity of the control plot despite improvement of drainage. Pyrites effected 1.5—1.6 unit reduction in pH of both top and sub soils, while aluminium sulphate caused only a reduction of 0.8 to 1.0 within a period of nine months. The effect of gypsum over the same period was much less than that of either aluminium sulphate or pyrites. The difference between 4 and 12 t/ha application was rather

Table 4.09. *Effect of three chemicals on soil acidity at Dalmore T.E. (data mean of 4 replications).*

Chemical	Rate of application t/ha	pH of soil				Reduction of pH	
		Before application of chemicals		Nine months after application			
		Top Soil	Sub soil	Top Soil	Sub Soil	Top	Sub
Nil (Control)	0	5.84	5.97	5.79	5.83	0.05	0.14
Aluminium Sulphate	4	5.99	6.20	5.28	5.45	0.7	0.8
	8	5.72	6.05	4.96	5.05	0.8	1.0
	12	6.00	6.19	5.14	5.30	0.9	0.9
Pyrites	4	5.86	6.01	4.41	4.88	1.5	1.1
	8	5.88	6.12	4.24	4.49	1.6	1.6
	12	5.82	6.01	4.12	4.26	1.7	1.8
Gypsum	4	5.90	5.95	5.25	5.46	0.6	0.5
	8	5.91	5.99	5.41	5.66	0.5	0.3
	12	5.81	6.02	5.69	5.66	0.12	0.36

negligible in case of all the three chemicals. The experiment is being continued to find out the long-term effects on both soil and yield of tea. The sharp drop in pH in laboratory pot experiment compared to the field trial is possibly due to the intensive leaching the soils were subjected to under laboratory conditions.

Trace elements

(i) Zinc levels in various plant fractions and correlation with dry matter content

A sand culture experiment was carried out in the glasshouse to establish critical levels of zinc in various plant organs and to correlate the same with yield. Zinc was supplied at the rate of 0, 0.008, 0.032 and 0.128 ppm in 200 ml of quarter strength Hewitt's solution per day for eight months, making a total supply of 0, 0.2, 0.8 and 3.2 mg Zn per plant. All other nutrients were supplied at one-fourth strength of Hewitt's solution.

Total zinc uptake (Table 4.10) increased in all plant organs with increasing levels of zinc application.

Table 4.10. *Zinc uptake by various plant fractions and the whole plant as influenced by the levels of applied zinc. as mg per plant.*

Plant fractions	Levels of application of zinc, mg/plant				
	0	0.2	0.8	3.2	Mean
Leaf	0.260	0.289	0.416	0.680	0.411
Stem	0.333	0.376	0.453	0.631	0.488
Branch	0.327	0.395	0.487	0.575	0.446
Root	0.740	0.808	0.930	1.147	0.906
Total plant	1.660	1.868	2.286	3.033	—

C.D. at 5% for leaf 0.175; for stem 0.141; for branch 0.092; for root 0.164; for total plant 0.131.

It was not possible to establish the critical level in any of the plant organs as zinc uptake continued to increase significantly with increasing levels of zinc, supply. Root contained the highest quantities of zinc followed by stem, branch and leaf in that order. Zinc uptake by the whole plant increased by 14, 38 and 80 per cent at application rates of 0.2, 0.8 and 3.2 mg/ plant respectively.

Of all the plant organs, leaf zinc concentration gave a significant correlation r=0.69 with yield (Fig. 4.04). Root C.E.C. also increased with increasing Zn supply, and uptake of zinc by the whole plant correlated significantly with root C.E.C. values (r = 0.85) as shown in figure 4.05.

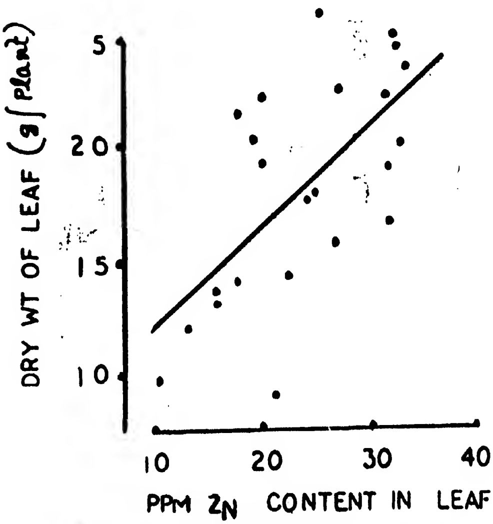


Fig 4·04. Relationship between leaf Zn content and dry matter.

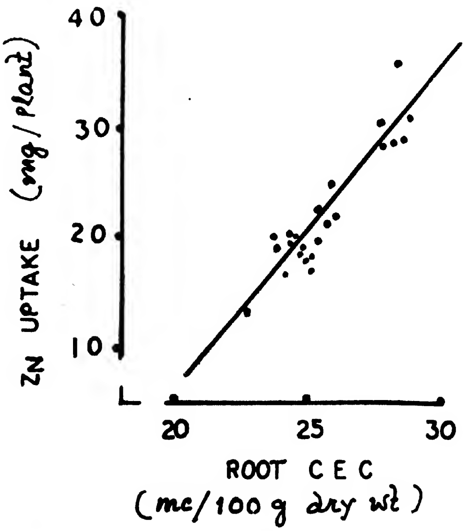


Fig 4·05. Relationship between root cation exchange capacity and Zn uptake by the whole plant.

(ii) Influence of manganese on nitrogen uptake by young tea

A pot culture experiment was conducted to find out the influence of manganese on nitrogen uptake. Young tea plants received nanganese at levels 0, 10, 20 and 40 kg Mn/ha as manganese sulphate and nitrogen at rates 0, 40, 80 and 160 kg N/ha as sulphate of ammonia in different combinations. Nitrogen uptake data of leaf, stem, root and the whole plant are given in Table 4.11.

Table 4.11. *Total uptake of nitrogen by plant organs in the presence of manganese. Gram nitrogen/plant organ/whole plant.*

Plant organ	Mn,kg/ha \ N,kg/ha	0	40	80	160	Mean
Leaf	0	1.357	1.403	1.047	1.112	1.230
	10	1.418	1.582	1.411	1.513	1.481
	20	1.435	1.548	1.580	1.808	1.593
	40	2.061	1.691	1.738	1.581	1.768
Stem	0	0.092	0.086	0.092	0.086	0.088
	10	0.123	0.124	0.091	0.116	0.113
	20	0.112	0.090	0.146	0.128	0.119
	40	0.140	0.106	0.169	0.162	0.144
Root	0	0.049	0.043	0.049	0.052	0.048
	10	0.041	0.052	0.043	0.039	0.044
	20	0.028	0.028	0.044	0.033	0.033
	40	0.025	0.028	0.029	0.030	0.028
Whole plant	0	1.496	1.532	1.188	1.250	1.366
	10	1.582	1.758	1.545	1.668	1.638
	20	1.576	1.666	1.770	1.969	1.745
	40	2.226	1.825	1.936	1.773	1.940

C.D. at 1% for leaf nitrogen 0.312; for N×Mn=0.174
C.D. at 1% for total plant nitrogen—0.389; for N×Mn = 0.217

Nitrogen uptake increased with increasing levels of manganese application mainly in leaf and whole plant, although this significant positive offect was not shown by stem and root. The interaction of manganese and nitrogen levels was also found to be significant in the case of nitrogen uptake by leaf and the whole plant. Manganese application at 10, 20 and 40 kg Mn/ha resulted in 20, 28 and 42 per cent increase in nitrogen uptake by young tea.

(iii) Influence of manganese on phosphate availability from sterilised and unsterilised soils

A pot experiment was carried out under glasshouse conditions to find out whether manganese augments uptake of phosphate by young tea. The soil used for this experiment was rich in available phosphate content (144 p.p.m.). Prior to imposition of treatments, one series of pots was sterilised, while the other series was kept unsterilised. Treatments comprised of application of manganese @ 0, 20 and 40 kg Mn/ha as manganese sulphate and phosphate @ 0,40 and 80 kg P_2O_5/ha as single superphosphate in both sterilised and unsterilised soils. The release of available phosphate (Bray I fraction) was followed at trimonthly intervals all through the year (Table 4.12). Plants will be harvested for uptake measurement at the end of 1981.

Table 4.12. *Release of available phosphate in the presence of manganese from sterilised and unsterilised soil (Mean of four sampling occasions and three replications).*

	p.p.m. available P_2O_5 released from unsterilised soil				p.p.m. available P_2O_5 released from sterilised soil			
Mn, kg/ha \ P_2O_5 kg/ha	0	40	80	Mean	0	40	80	Mean
0	110	121	136	122	94	138	146	126
20	104	134	156	131	99	137	148	128
40	95	139	165	133	109	143	134	129
Mean	103	131	152	129	101	139	143	128

C.D. at 5% for unsterilised Soil 10.02   C.D. at 5% for sterilised soil 22.70

The effect of manganese and the interaction of manganese and phosphate on the release of available phosphate were highly significant in case of unsterilised soil, but these effects were not observed in sterilised soil. Soil available phosphate, however, increased significantly with increasing level of phosphate application in case of both steirlised and unsterilised soils.

iv) Relationship between total and available boron in soil profiles of tea growing areas

Relationship between available (hot water soluble) and total boron in some of the South Bank and North Bank soils is shown in Table 4.13.

Both total and available boron (hot water soluble) decreased with depth, specially from 60 cm downwards. In the South Bank, (Jorhat and Nazira) soils were relatively richer in available and total boron contents

Table 4.13. *Relationship between available and total boron in different depths of tea soils (mean of three estates in each sub-district and expressed as p.p.m. boron content.*

District	Sub-district	Available boron 0-30 cm	50-60 cm	60-90 cm	90-120 cm	Total boron 0-30 cm	30-60 cm	60-90 cm	90-120 cm	Available B as p.c. of total B 0-30 cm	30-60 cm	60-90 cm	90-120 cm
South Bank	Nowgong	0.15	0.12	0.08	0.11	11.90	12.02	9.47	9.08	1.26	1.00	0.84	1.20
	Golaghat	0.19	0.15	0.10	0.10	14.10	13.07	13.07	12.29	1.35	1.15	0.80	0.81
	Jorhat	0.31	0.22	0.20	0.10	24.37	22.40	21.35	16.87	1.27	1.00	0.94	0·60
	Nazira	0.22	0.14	0.13	0.10	22.44	20.50	19.35	19.10	1.00	0.70	0.67	0.52
North Bank	Mangaldai	0.44	0.42	0.33	0.32	25.00	22.73	18.30	17.70	1.80	1.80	1.80	1.80
	Tezpore	0.16	0.18	0.17	0.16	10.20	10.30	9.60	8.80	1.60	1.70	1.80	1.80
	Bishnath	0.20	0.19	0.14	0.13	13.10	12.70	10.80	10.60	1.51	1.51	1.34	1.32
	North Lakhimpur	0.17	0.16	0.12	0.10	12.50	12.40	11.50	9.50	1.43	1.34	1.00	1.00

than Nowgong and Golaghat soils. In the North Bank, (Mangaldai) soils were much higher in total and available boron contents than the soils of other sub-districts of North Bank, which were relatively lower in total boron content compared to the South Bank soils. The available boron contents of these latter soils were, however, similar to those of South Bank soils. About 1 per cent of the total boron remained available in South Bank soils, specially in the top 60 cm layer, while in North Bank soils, about 1.5 to 1.8 per cent of the total boron remained in an available state with the exception of North Lakhimpur soils. The general trend of higher order of availability of boron in North Bank soils (mostly new alluvium) may be linked with the mineralogical differences between the old (South Bank) and the new alluvium (North Bank).

(v) Influence of boron and calcium on the release of available boron and calcium from soil

A pot experiment was carried out to find out the changes in available boron and calcium content of soil as well as boron (B) and calcium (Ca) uptake by young tea at different levels of B and Ca application. Treatments comprised of application of boron as boric acid @ 0, 1, 2 and 4 kg B/ha and of calcium as calcium sulphate @ 0, 10, 20 and 40 kg Ca/ha in sixteen combinations. Changes in available calcium on four sampling occasions and three replications are graphically shown in Fig. 4.06.

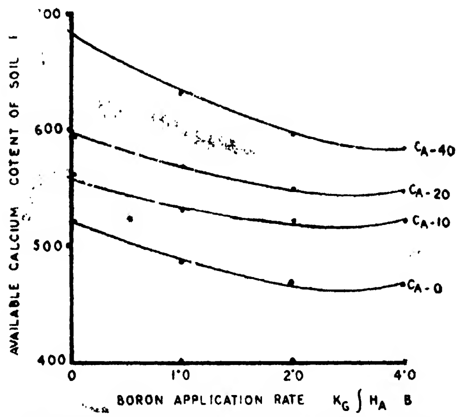


Fig 4.06. Influence of Boron on the available calcium content of Soil.

Fig. 4.06 shows clearly the negative effect of boron on the available calcium content of soil, which was very much pronounced at 40 kg/ha calcium application. The positive effect of calcium ($P<0.001$) and the negative effect of boron on soil available calcium content were highly significant ($P<0.001$). The negative interaction between B and Ca on the soil available calcium content was also highly significant ($P<0.001$).

Table 4.14 shows the changes in soil available boron content as affected by boron and calcium application.

Table 4.14. *Influence of B and Ca application on available B content of soil (mean of four sampling occasions and three replications, expressed as p.p.m. B).*

Calcium kg/ha \ Boron kg/ha	0	1	2	4	Mean
0	0.036	0.074	0.121	0.379	0.152
10	0.029	0.068	0.094	0.282	0.118
20	0.026	0.068	0.089	0.217	0.100
40	0.018	0.058	0.058	0.201	0.090
Mean	0.027	0.067	0.097	0.270	0.115

C.D. at 1%, for boron and calcium = 0.088;
for calcium × boron = 0.049

The positive effect of boron ($P<0.001$) and the negative effect of calcium ($P<0.01$) on the soil available boron content was found to be highly significant. The interaction of B × Ca on available boron content was also highly significant ($P<0.01$). The negative effect of calcium on available B was most pronounced at the highest rate of boron application, i.e. @ 4 kg B/ha.

Plants will be harvested at the end of the year for uptake measurement of boron and calcium.

Influence of soil physical conditions on growth, yield and nutrient uptake

Physical conditions studied were ground water table, compaction, soil moisture and soil temperature under conditions of model tank and micro-plot experiment respectively. Some of the results are described hereafter :

(i) Water table and soil moisture

The control of water table in model tanks at 90 cm consistently resulted in good growth and significantly higher yield compared to the tanks where water table was kept controlled at 45 cm and 135 cm respectively. When water table was fixed at 135 cm, the soil layers at 15 cm intervals from surface down to 90 cm depth had significantly lower moisture content than that of 90 cm water table. When the water table was controlled at 45 cm the top layer (0-15 cm) remained practically in a super-saturated condition. However, no significant difference in soil moisture at lower (30-45 cm) depth was observed between 45 cm and 90 cm water tables. Fig. 4.07 shows the soil moisture regime (mean of depth) of various tanks. Work is in progress to find out whether soil aeration becomes critical under high water table conditions (45 cm or above). To explain the observed adverse effect of 135 cm water table on the growth and yield of tea, water balance is being computed in the three series of tanks.

(ii) Water table and soil temperature

The trends of changes in soil temperature profile (depthwise) with season were found to be of similar

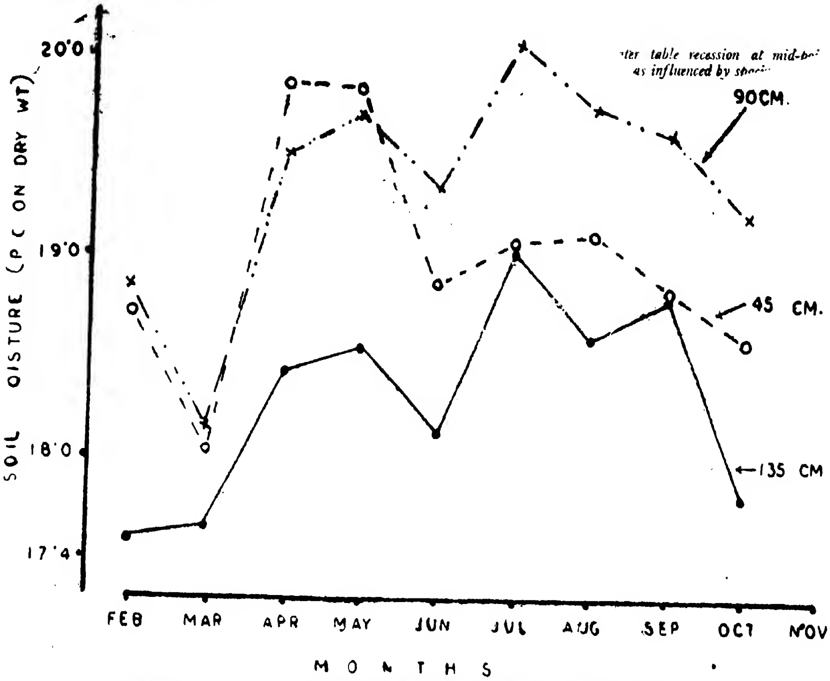


Fig 4.07. Influence of controlled water table on soil moisture regime.

nature for all the three tanks having controlled water table at 45, 90 and 135 cm. From February to August soil temperature tended to decrease with depth. Comparison between the tanks showed that, in general, soil temperatures at all depths under 135 cm and 90 cm were much higher than under 45 cm water table, which could be due to the supersaturated moisture regime of the latter.

(iii) **Compaction and moisture**

In a preliminary microplot experiment soil : vermiculite at 70:30 and 50:50 ratios were mixed with loamy sand, sandy loam and silty loam soils. Vermiculite at both ratios remarkably benefitted both root and top growth of young tea in loamy sand soils, but not in sandy loam and silty loam soils. Moisture retention capacity of both loamy sand and sandy loam soils improved considerably with 50:50 : soil : vermiculite ratio, whereas vermiculite in the same ratio decreased the moisture retention capacity or increased porosity of silty loam soil. Aggregate analysis of the treated soils showed that the increase or decrease of moisture retention capacity of soils due to treatment with vermiculite is associated with the changes in aggregate size distribution, specially of the 1 to 5 mm dimentions.

This experiment has now been repeated using the same soils and same ratios of soil and vermiculite. It is intended to study loss of nutrients, nutrient uptake and growth of root and top of the young clonal tea in addition to the changes in soil physical properties.

A pot experiment is also in progress, where the effect of various moisture regimes (field capacity, $\frac{3}{4}$ th field capacity and half field capacity) and degree of compaction (1.4, 1.6, 1.8 and 2.0 g/cc) on root growth and nutrient uptake are being studied.

Surveys of the physical factors of the tea soils of North East India

Permeability (K) of sub-soil (below water table) was determined by auger hole method. The range of K-values determined by this method in case of sandy loam soil at Tocklai has been found to be 0.7—2.0 m/day. Work is also progressing for determining K-values in the laboratory using ICW permeameter and undisturbed soil cores. Preliminary measurements showed considerable variations between the cores drawn from the same area at a certain depth. The range of variation at 60 cm depth was found to be between 0.2—2.0 m/day for sandy loam soil. Further work is now being carried out to determine the optimum sample size for accurate estimation of K values using undisturbed core samples and correlating these with the K values obtained *in situ* by the auger hole method. Development of a reliable laboratory method merits special consideration because of non-availability of desired field conditions (below water table) for most part of the year for using the auger hole method.

Wa...

A study w..nd Golaghat soils. d out the behaviour of water table at some of ...h hig' estates of South Bank during monsoon months. The water table range was divided into a few classes. Fig. 4.08 shows the cumulative frequency of occurance of water table classes

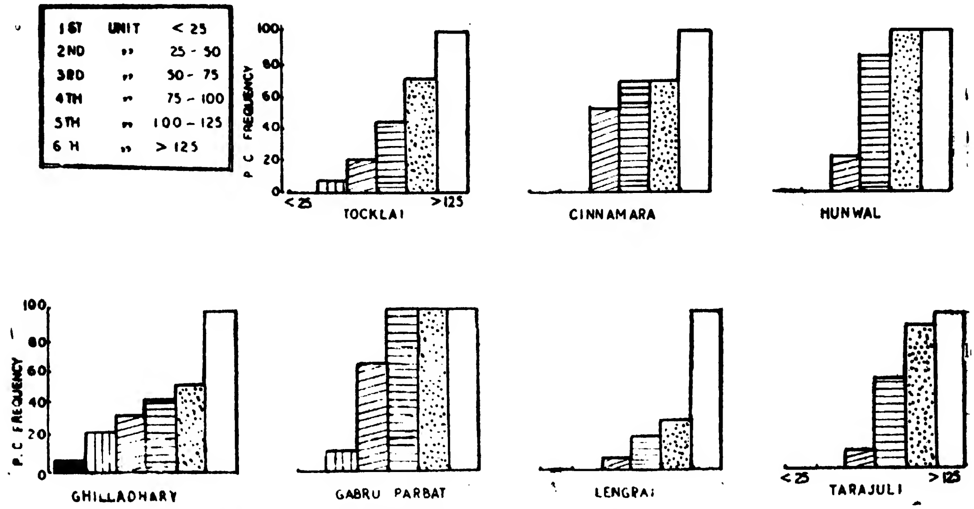


Fig 4.08. Percentage cumulative frequency distribution of water Table classes

during monsoon season at the central part of the tea sections under study. It may be mentioned that the depth of water table varied between the sections as well as within the section depending upon soil, topography and existing drainage conditions. Different nature of water table behaviour was thus observed in the same tea estate but at different sites. If half of the cumulative percentage frequency is considered as representing the average water table situation of an estate then in terms of increasing water table depth, the estates followed the order :

Lengrai > Ghilladhary > Tocklai > Hunwal > Tarajuli > Cinnamara > Gabroo Parbat.

The areas were also identified from the point of view of recession of watertable after the peak rise. This was done by finding out the time taken for recession of the groundwater table from the highest to the original levels. The following order of increasing ground water removal rate was observed in the estates surveyed :

Hunwal > Tarajuli > Tocklai > Cinnamara > Ghilladhary > Gabroo Parbat > Lengrai.

Although Lengrai and Ghilladhary had lower water table at more frequent intervals, their time of recessing was relatively slower than others like Hunwal, Tarajuli and Tocklai (which showed higher average water tables at higher frequency). It is, therefore emphasised that lesser frequency of high water table does not indicate better drainage situation. Far more important is the ground water removal rate and the two criteria together determine the efficiency of the adopted drainage system. On the considerations of both parameters, Hunwal, Tarajuli, Tocklai appear to be better drained than Ghilladhary and Lengrai.

This study also aimed at finding out presence of hard pan, if any, in the areas under investigation which might result in high water table. Piezometric observations at various depths did not indicate the existence of any hard pan in the areas included in this survey.

Pipe drainage experiment

The observations on the depth of water table and drain discharge were continued during the year as before in Tocklai Division pipe drainage experiments (Nos. 3 and 4, details in Ann. Sci. Rep., 1979-80, p.39). Drain discharge could not, however, be measured during peak storm periods in pipe drainage experiments at Haroocharai T.E. (Expt. Nos. 1 and 2. c.f. Ann. Sci. Rep., 1979-80, p. 39) due to high water levels in the main channel at that estate.

(i) **Water table hydrograph**

Figs. 4.09 and 4.10 show the midpoint water table hydrographs recorded at drain spacings of 23.0 m (P.V.C. pipe), 35.3 m (P.V.C. pipe), 17.8 m (cement asbestos pipe) and 17.8 m (open drain). The number of occasions when water table rose to different heights below the ground surface during 1980 rainy season are shown in Table 4.15.

Table 4.15. *Rise of ground water table as influenced by drain spacings, open channel and sub-surface drainage systems.*

Depth of water table cm	Number of occasions when water table was observed at depths			
	23.0 m P.V.C.	35.5 m P.V.C.	17.8 m cement asbestos	Control (17.8m open channel)
50	None	None	None	None
70	"	3	2	1
90	"	8	3	17
100	"	13	7	25

It is seen from the table that irrespective of the spacings or the nature of the drainage system, ground water table remained below 70 cm almost throughout the rainy season.

However, water table recession time (i.e. duration of waterlogging) gave better indication of the extent of waterlogging under different spacings and the drainage systems. The water table recession data during five consecutive days after cessation of a peak storm on 31st August, 1980 are given in Table 4.16 for various drainage plots.

From the table it is seen that system 3 (P.V.C. pipe, *9 cm dia* 23 m spacing) was most effective in controlling water table at a depth of 135 cm ($4\frac{1}{2}$ ft)

Table 4.16. *Nature of water table recession at mid-point between two lateral drains as influenced by spacing and drainage systems.*

Drainage system and spacing	Initial water table depth immediately after storm in cm	Water table depth after cessation of storm in cm				
		1st day	2nd day	3rd day	4th day	5th day
1. Control, open channel 17.8 m spacing	77	110	116	114	131	137
2. Cement asbestos pipe 5 cm dia, 17.8 m spacing	75	119	142	148	152	156
3. PVC slotted pipe, 9 cm dia, 23 m spacing	106	135	142	145	149	152
4. PVC slotted pipe 9cm dia. 35.5m spacing	58	95	116	123	131	149

within 24 hrs., followed by system 2 (cement asbestos pipe, *5 cm dia.*, 17.8 m spacing), which produced the same result within 48 hours. Nature of water table recession, however, did not differ much between open channel (system 1) and 9 cm P.V.C. pipe at 35.5 m spacing (system 4). Thus, it appears that the diameter of the underground pipe and their spacing interact in effective control of water table after peak storms.

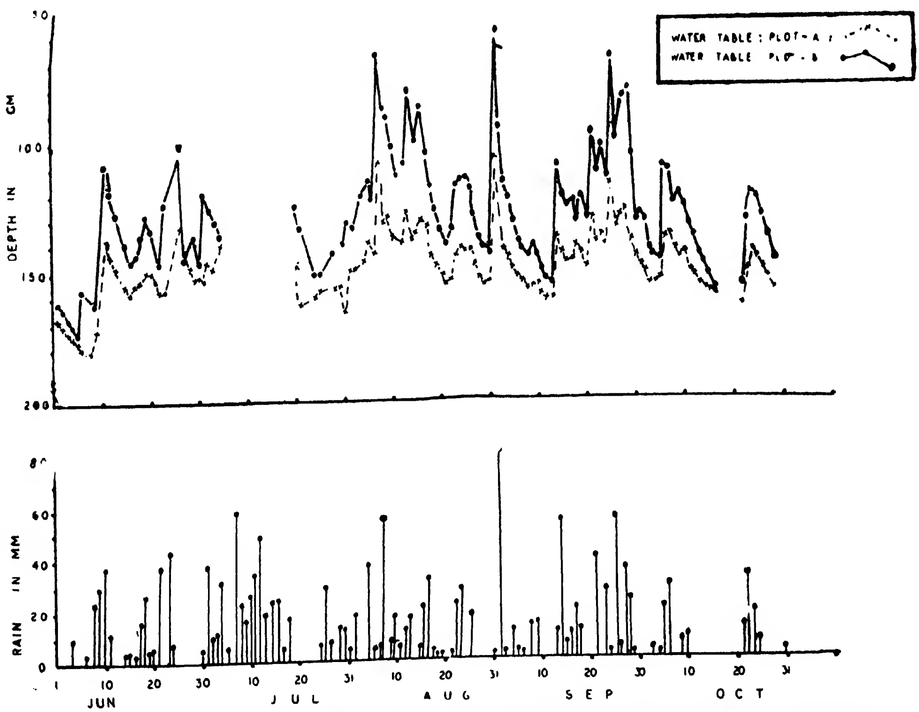


Fig 4.09. Tocklai mid point watertable hydrograph and rainfall (plot A 23.0 m spacing and plot B 35.5 m spacing, P.V.C. slotted pipe 9 cm diameter.

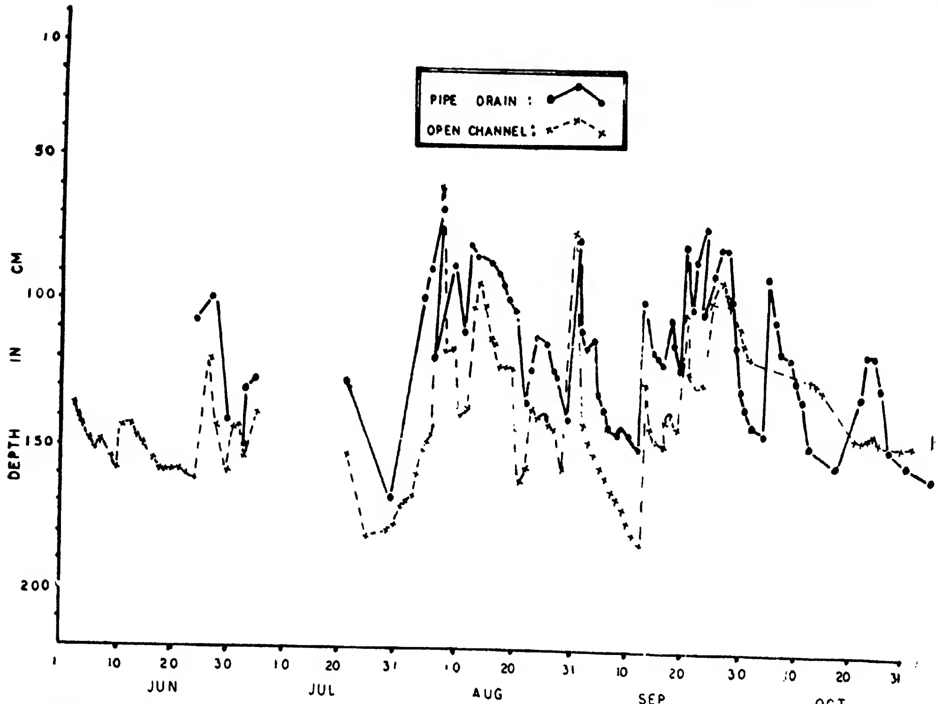


Fig 4.10. Tocklai division water Table (cement asbestos pipe drain, spacing 17.8 m, 5 cm diameter; open channel 17.8 nm spacing).

(ii) **Drain discharge**

Drain discharge measurements were carried out adopting bucket and stopwatch method during the periods of drain flow. Discharges were measured thrice daily. The discharge rates also showed similar variations as those observed with ground water table. The variations in peak discharge rates for selected storms in case of two pipe drain plots having different diameter of pipes at different spacings are given in Table 4.17.

Table 4.17. *Variations of peak discharge rates as influenced by spacing and drainage systems.*

Dates of selected storms	Rainfall mm	Discharge rate of pipe drains at			
		35.5 m spacing (9cm dia P.V.C. pipe)		17.8 m spacing (5 cm dia. cement asbestos pipe)	
		Lt/main (rate)	mm/day amount)	Lt/main rate)	mm/day (amount)
13.8.80	40	15.4	11.1	8.6	11.4
16.8.80	30	12.2	8.8	7.6	10.1
31.8.80	80	37.5	27.0	27.3	36.2
20.9.80	38	12.0	8.6	8.3	11.0
24.9.80	53	24.8	17.8	14.2	18.8
27.9.80	23	20.0	14.4	10.0	13.3

It is seen from the above table that the drain discharges from 17.8 m spacing (pipe diameter 5 cm) and 35.5. m spacing (pipe diameter 9 cm) compared favourable in most occasions, but on 31.8.80 during the peak storm of 80 mm, closer spacing gave much higher amount of discharge compared to the wider spacing. Accordingly water table recession varied greatly as shown in Table 4.16. Both discharge data and the nature of water table recession during the peak storm period emphasise that diameter of the pipe and the spacing interact in controlling water table within a resonable period (24-48 hrs) after cessation of the storm. Increasing the diameter of the pipe drain proportionately with the spacing did not result in ensuring same amount of drain discharge following a peak storm and, as such, water table recession took a longer period to attain the same depth of water table under wider spacing of 35.5 m (as mentioned earlier). Thus increase of the diameter of drainage pipes does not compensate for proportionate decrease in drain spacing to achieve similar magnitude of water table control within a resonable period.

METEOROLOGY

Analysis of long-term rainfall data recorded at Nagrakata

Depth-duration-frequency anaylsis of long-term rainfall data recorded at Nagrakata meteorological observatory was carried out during the year. The method adopted is the same as that described in Ann.

Sci. Rep. for 1979-80 (p. 44). Analysis was carried out for the main monsoon months of June, July and August based on 20 years data (1961-80) to obtain information on the peak storm for designing drains.

The analysis showed that the amounts of rain falling for a period of one day or periods of 2, 3, 4, and 5 consecutive days are maximum in the month of July compared to June or August and this was true for return periods of 5, 10, 20 or 100 years Fig. 4.11 shows the depth-duration-frequency curves for Nagrakata, Dooars for the months of June, July and August.

It was also observed that the intensity of rain per day decreases considerably after the third donsecutive day during June, whereas similar decrease beyond third day was not observed for the months of July and August. In July and August, increasing periods of duration beyond three consecutive days showed distinct upward trends in the intensity of rainfall (Fig 4.11).

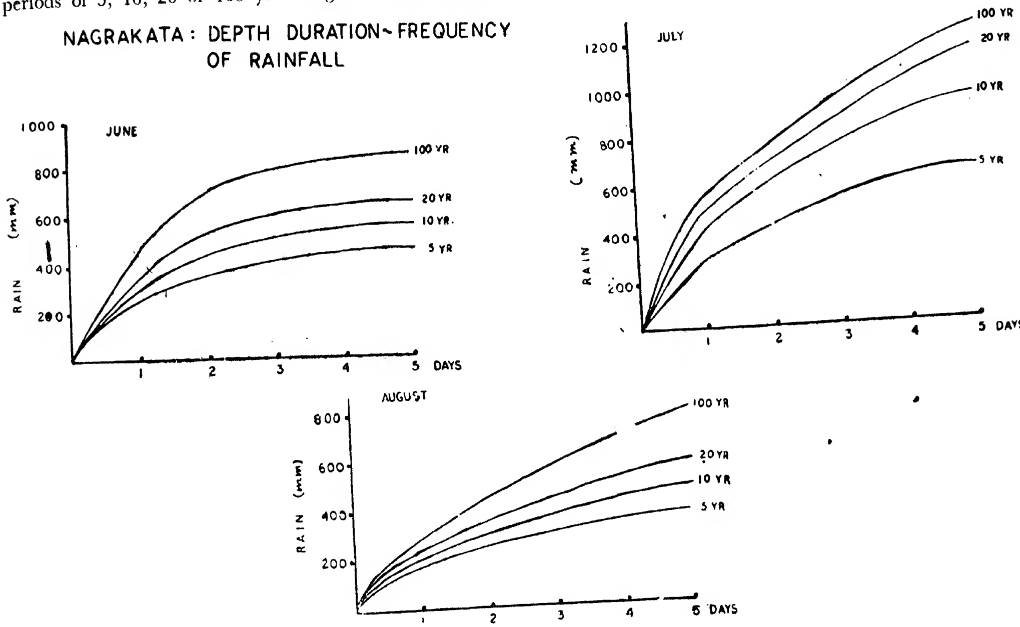


Fig 4.11. Depth Duration frequency rainfall curve under Dooars condition for June, July and August.

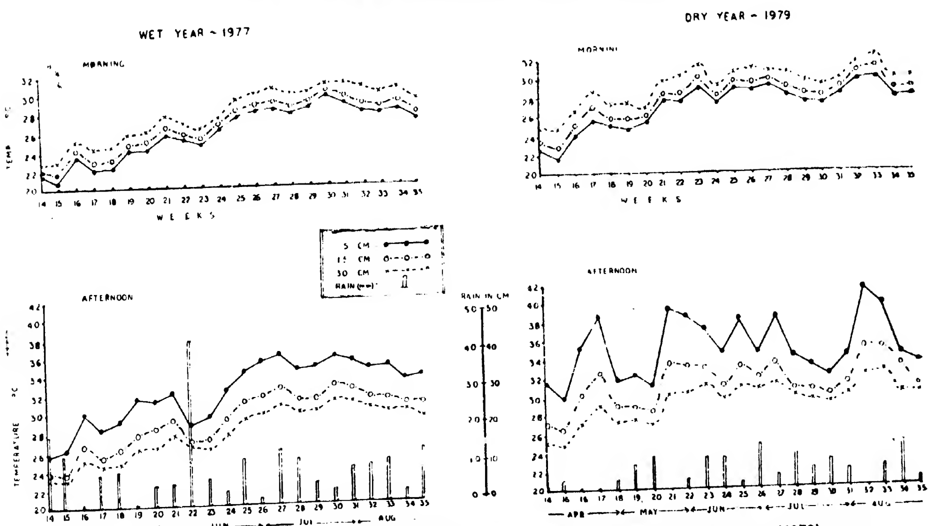


Fig 4.12. Variation of soil temperature (Tocklai) during wet (1977) and Dry (1979) years

Rainfall depth (amount) and intensity for June, July and August for a five year return period are given in Table 4.18.

Table 4.18. *Quantity and intensity of rainfall for June, July and August at Nagrakata, Dooars for a five year return period.*

Duration in days	June mm rain	June intensity mm/day	July mm rain	July intensity mm/day	August mm rain	August intensity mm/day
1	230	230	290	290	160	160
2	360	180	415	207	225	112
3	410	137	490	163	280	93
5	470	94	570	114	385	77

Data show that a rainfall input of 163 mm/day will be a reasonable estimate of storm intensity for the Dooars

Soil Temperature

The influence of rainfall on the variations of soil temperature at different depths during morning and afternoon hours of a wet and a dry year is shown in Fig. 4.12. Much more than the normal quantum of rain was received during the April-August period of 1977, while much less than the normal rainfall occured during the same period of 1979. As such 1977 and 1979 are described as wet and dry years respectively. During this period the soil temperature at 5 cm depth remained much higher during both morning and afternoon hours in the dry than in the wet year. The soil temperature differences in the morning hours at 15 and 30 cm depths between the dry and the wet years were not appreciable, although in the afternoon hours, the soil temperature at 15 cm depth was significantly higher

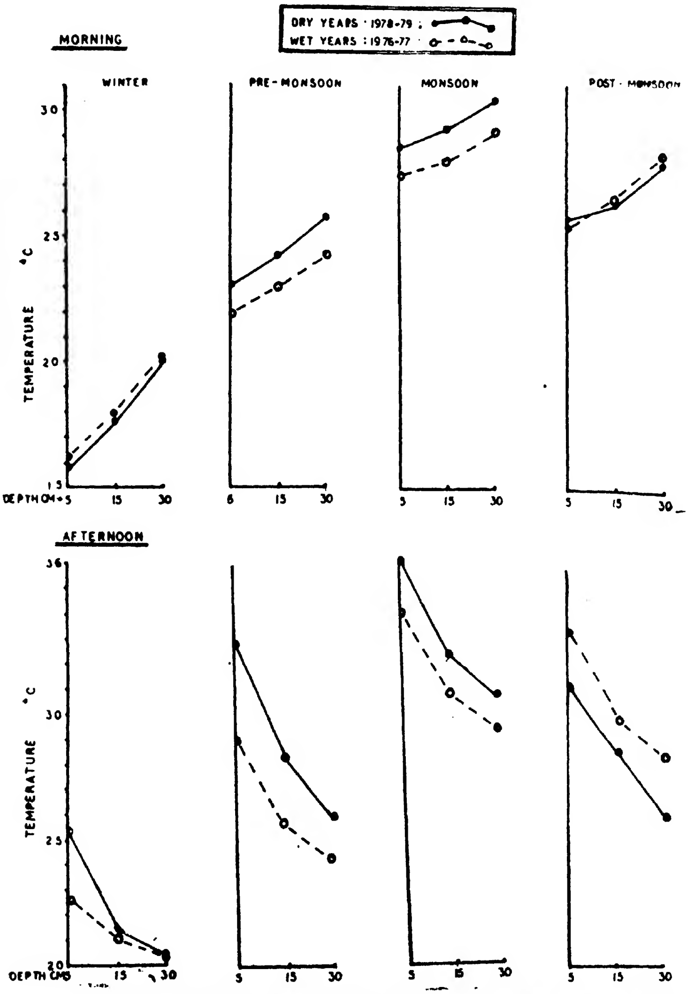


Fig 4·13. Variation (seasonwise) of soil temp. during dry and wet years

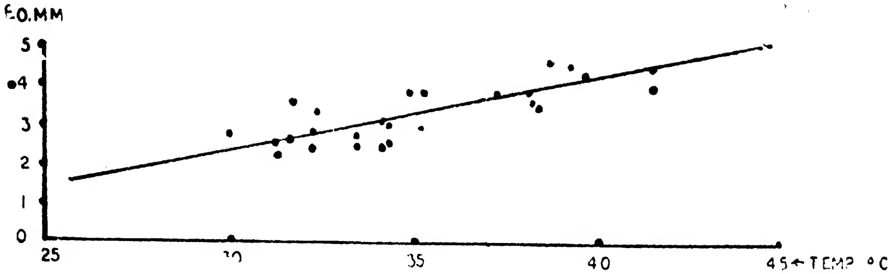


Fig 4.14. Relation between evaporation and Soil Temp. (5 cm afternoon) during dry year (1979).

in the dry than in the wet year. However, the effect of rainfall on lowering the soil temperature, specially at 5 and 15 cm depth was much pronounced in the dry year. These variations in soil temperature for the pre-monsoon, monsoon and winter seasons are presented in Fig.4.13.

Fig. 4.14 shows the linear relationship ($r=0.78$) between evaporation (as estimated in Class A Pan) and soil temperature at 5 cm depth during the dry year of 1979. As the soil temperature increased, evaporation increased significantly ($P<0.1$). Thus temperature of the top 5 cm soil layer in a dry year can be a major factor contributing for evaporation.

Meteorological Data

Meteorological observations were carried out throughout the year in seven Class 'A' observatories at Tocklai, Margherita, Thakurbari, Silcoorie, Nagrakata, Gungaram and Nagri-Farm. Summarised data are given in Appendix—D of this report. Besides, total monthly U.S. Pan evaporation data of thirteen sites are also given in Appendix - D.

Advisory Soil Analysis :

A total of 59,330 soil tests were carried out for advisory purpose alone, the break-up being :

Laboratory location	No. of soil samples (from 1.4.80 to 31.3.81)	No. of tests carried out
Tocklai	13,098	42,119
Nagrakata	8,773	17,211

Highlights

1. *Two promising biclonal stocks are in the pipeline for release to the industry in near future.*
2. *Six outstanding clones from the vegetative selections have been put under district trial to evaluate their performance in different agro-climatic conditions for their final release.*
3. *Under district selection scheme eleven estates were surveyed from which 457 mother bushes were selected.*
4. *The major component of promoters in tea shoots appear to be GA_3. Promotion of flushing by foliar spraying of gibberellins is evident although the response varies with season depending up on the climatic conditions. The seasonal effect is confounded with the response of gibberellins.*
5. *Possibility of using CEPA or CCC at 100 ppm foliar spray as a tool for temporary crop suppression has been established.*
6. *CEPA at 1000 ppm and Oxyflurofen at 500 ppm foliar spray two months after planting promotes lateral growth in young tea.*
7. *Direction of movement of photosynthates from the maintenance canopy and starch reserve in roots may serve as an index for deciding the time of pruning in mature tea.*
8. *Stomatal behaviour of tea leaves is examined with the object of using it as a criterion for screening progenies for drought tolerance.*

PLANT IMPROVEMENT

Biclonal stock Trial

The long-term trial of seven biclonal stocks at Tocklai (Annual Report 1978-79, p 45) was continued during the year. Apart from the TS 462, which was released to the industry in 1980, two more biclonal Stocks which have performed significantly better than the released stocks, TS 203 and TS 449, are likely to be released in near future.

Seeds from three micro seed baris, TS 490, TS 491 and TS 492 (Annual Report 1977-78, p 39) were distributed to different outstations and Nagrakata sub-station for long-term trials.

Ten micro-seed baries were established during the year with various combinations of eleven combiner clones selected earlier from pollination studies.

Selection of Vegetative Clones

The long-term trial of clones with more than 110 clones were continued during the year. Out of about 30 promising clones, six outstanding clones were sent to various outstations and Nagrakata sub-station for trial under different agro-climatic conditions before their final release to the industry.

One more long-term trial was planted this year with nine clones selected from a China-hybrid population.

District Selection Scheme

Under the scheme, bush selection was taken up in 11 more estates from which 457 mother bushes were selected. Table 5.01 sums up the current position of the scheme.

Table 5.01. *Tea estates surveyed and number of bushes selected.*

Region	No. of estates surveyed		Total area surveyed (ha)		No. of mother bushes selected	
	1980-81	1975-81	1980-81	1975-81	1980-81	1975-81
Assam						
South Bank	5	46	184.87	1609.60	214	1938
North Bank	4	34	160.77	1605.36	173	1396
Cachar	—	9	—	479.66	—	280
Tripura	—	3	—	118.44	—	90
Dooars	1	22	60.00	1256.80	39	993
Terai	1	8	48.29	544.44	31	283
Darjeeling	—	9	—	298.01	—	254
Total	11	131	453.93	5912.31	457	5234

The selection team also visited about 84 estates during the year as a follow-up measure for schemes undertaken earlier. Apart from 10 long-term trials of clones established in 1980-81 in different estates, two Clonal Proving Stations, one at TRA Thakurbari and the other at Monabari T.E., were also established. These two CPS include 60 and 20 clones respectively, selected from the estates in the neighbouring region. Details are given in Table 5.02.

Polyploid breeding

Out of the 89 polyploid stocks developed at Tocklai (Annual Report 1979-80), 56 clones were planted out in a replicated trial for evaluating cup quality and field performance. Initial observations indicate a number of promising clones.

Mutation breeding

Initial results of irradiation of clonal cuttings and seed stocks by gamma rays were reported earlier (Annual Report, 1979-80, pp 50-51). The resultant seedlings are under study to detect any useful mutants.

PLANT PHYSIOLOGY

Seasonal dormancy:

A systemic study on the mechanism of dormancy has been continuing for the last few years. Results of past experiments (Annual Report 1974-75, p 34; 1975-76 p 29; 1977-78 p 41; 1978-79, p 47; 1979-80, p 51) indicate that both short day-length and low temperature play important roles in inducing winter dormancy. However, it was not possible to eliminate the dormancy completely by exposing tea plants to equivalent mean summer day and night temperature and day-length under growth room conditions. This indicates the complexity of factors controlling bud dormancy which

Table 5.02. *Long-Term trial with clones selected in tea estate.*

Region	Site of L.T. trial.	No. of clones included in the trial: Estate	No. of clones	Date of planting trial	
Assam South Bank	In the estate	Deepling	35	April,	1980
	,,	Namburnadi	16	,,	,,
	,,	Gabroo Purbat	13	May,	1980
	,,	Gopal Krishna	27	May	1980
	,,	Borbam	13	November,	1980
	,,	Borahi	19	December,	1980
	,,	Bukhial	23	February,	1981
Assam North Bank	CPS Monabri	Baghmari	10	August,	1980
	,,	Borgang	3	,,	,,
	,,	Gohpur	3	,,	,,
	,,	Halem	4	,,	,,
	CPS Thakurbari	Kolony	12	,,	,,
	,,	Kacharigaon	5	,,	,,
	,,	Sonabheel	9	,,	,,
	,,	Phulbari	6	,,	,,
	,,	Sonajulie	9	,,	,,
	,,	Dhulapadung	6	,,	,,
	,,	Rupajuli	7	,,	,,
	,,	Tezpore & Gogra	6	,,	,,
	In the estate	Dhunseri	11	September	1980
Assam Cachar	In the estate	Borojalinga	9	September,	1980
	,,	Longai Valley	10	,,	,,

List of long-term trial established earlier is given in appendix "B".

needs thorough investigation. Bioassay of growth regulating substances indicated that the balance of growth promoting (auxins, gibberellins and cytokinins) and growth retarding (abscisic acid) substances controls the state of growth or dormancy in a tea bush. This was confirmed by exogenous application of Gibberellic acid (GA_3) which induced bud break and growth during winter, leading to increase in early season's crop.

The growth regulating chemicals present in growing and dormant buds and leaves of tea were extracted, purified and fractionated by paper chromatography into 10 Rf bands. The growth promoting or growth retarding activity of the chemicals at each Rf band was estimated by the bioassay technique, using mustard hypocotyl as the test material (Das., Ph.D Thesis,1977). Attempt was then made to identify the growth regulating chemicals present in different Rf bands by measuring absorbance in a spectrophotometer.

The absorbance (λ) pattern of the elute from 0.5-0.6 Rf band where the peak activity of growth promoting substance was observed, in comparision with that of pure GA_3 (Abbot Chemicals, USA) is shown in Fig.5.01.

The peak absorbance in the tea extract appeared at 226 nm and of pure GA_3 at 225 nm (Fig. 5.01). Hence, the active substance present in the elute of 0.5-0.6 Rf band appears to be GA_3. The absorbance peaks for Rf 0.0-0.1 to 0.4-0.5 appear between 230-250 nm and those of Rf 0.7-0.8 and 0.8-0.9 appeared between 260-270 nm, but these peaks were flattened. The cause/s may be presence of impurities in the elutes or the presence of other growth promoting substance.

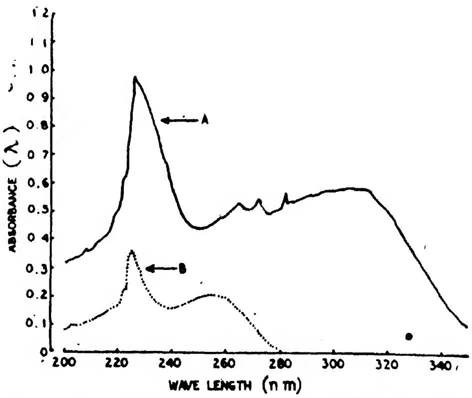


Fig 5.01. Absorbance (λ) at different wave-lengths (nm) in the UV range. A. elute from Rf 0.5-0.6 band of paper chromatogram. B. pure GA_3.

Growth regulators on Crop distribution

Further to the results reported last year (Annual Report 1979-80, p 52) the experiment was continued on the pruned plants of clone 107/16 and 107/19 during 1980 season repeating the spray of gibberellin combinations at different doses. The crop response of the two clones in terms of yield per unit area (gm. M^{-2}) during July, October and November is reported in Table 5.03.

Quantity of spray:	GA_3	$GA_3 + GA_{4,7}$
July	50 ppm	25 + 25 ppm
October	50 ppm	50 + 50 ppm
November	100 ppm	50 + 50 ppm

Table 5.03. *Yield in gm. M^{-2} for repeated spraying of gibberellins*

Clone	Treat	July Spray: Aug. 1– Sept. 30	% over control	Oct. Spray: Oct. 7– Nov. 6	% over control	Nov. Spray: Nov. 13– Dec. 8	%over control	Total Crop: July – Dec.	% over Control
107/16	GA_3	616	17	269	29	197	76	1082	28
	GA_3 + $GA_{4,7}$	501	-5	222	6	134	20	857	1
	Control	526		209		112		847	
107/19	GA_3	545	19	219	23	123	38	887	22
	GA_3 + $GA_{4,7}$	421	8	182	2	100	12	703	3
	Control	459		178		89		726	

There was better response to foliar spraying of GA_3 alone at 100 ppm than to the combination spray of $GA_{4,7}$ with GA_3. Similar response was obtained during 1978. Perhaps the endogenous level of gibberellins changes from season to season, requiring external gibberellins to initiate bud break and flushing. Investigations on isolation, identification and qualification of the gebberellins are underway.

Possibility of temporary crop suppression during peak season by foliar spraying of growth retardants like ethephon (CEPA) and cycocel (CCC) at 100 ppm has been confirmed this year also on Assam, Cambod and China clones. The growth is supressed for about 2-3 weeks and the suppression is made good in the following 4-5 weeks (Fig.5.02.) Past observations indicated that quality of made tea was not adversely affected by growth regulator sprays. In future trials this aspect is intended to be studied further.

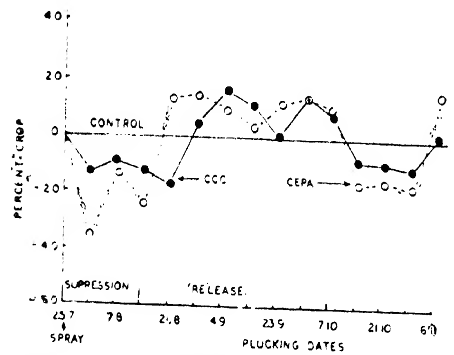


Fig 5·02. Effect of Ethephon and cycocel on crop supression in tea (TV15. 1980

Growth regulators for branching in young tea

Field experiments were taken up in Heeleakah T.E., and Tocklai for confirmation of the results reported last year (Annual Report 1979-80, p 52-53)on girth and lateral production. Foliar spraying of ethephon (CEPA) at 1000 ppm, Cycocel (Chlormequot chloride) (CCC) and daminozide (SADH) at 2000 ppm increased stem girth of plants. However, only CEPA at 1000 ppm and goal (Oxyflurofen) at 500 ppm promoted lateral production to the extent 50 per cent more than control. (Table 5.04). Clones varied in their response to treatments. Results of previous as well as the current experiment indicate that ethephon (CEPA) at 1000 ppm foliar spray two months after planting in the field appears promising in inducing branching. Further observations are continued.

Table 5.04. *Mean number of lateral branches following application of growth retardants.*

Treatments	Heeleakah T.E. Teen Ali 17	Tocklai Division TV20, TV22 & TV23	New Botanical Area TV1	Mean
Control	3.60	2.22	1.73	2.52
CEPA 1000 ppm	4.47*	2.82*	2.27	3.19
CCC 2000 ppm	4.17	2.31	1.97	2.82
SADH 2000 ppm	3.98	2.42	1.73	2.71
GOAL 500 ppm	5.45*	2.91*	3.37*	3.91
C.D. at 5% level of probability	0.678	0.273	1.014	

*Significant at 5% level of probability
Figures are the mean of 3-4 blocks, each with 10-20 plants after centering between 15 and 20 cm.

Photosynthesis and translocation studies using ^{14}C-isotope. Studies on maintenance foliage:

In order to determine the appropriate time of pruning and resting of bushes based on the direction of movement of assimilates from the maintenance canopy and starch accumulation in roots, observations on the direction of movement of assimilates from different maintenance leaves during October, 1980 to February, 1981 were made in the pruning experiment at Daimukia T.E. of Doom Dooma Tea Co., Ltd. using radioactive carbon.

Bidirectional movement of assimilates (Upper layers towards shoots and lower layers towards roots) from the maintenance canopy was observed during mid-October and mid-February, indicating the transition period of building up and utilisation of root reserves. Flow of assimilates from the top layers of leaves

is faster (10-12 cm/hr) compared to the lower layers (5-6 cm/hr). However, the fourth leaf from apex in a tipped stem does not often follow the general pattern of distribution of assimilates. The cause of this behaviour is under study.

Chemical analysis of root samples for starch indicated a gradual build up of starch from 10% in October to a maximum upto 21% in the month of February (Table 5.05). The direction of movement of assimilates from the maintenance canopy and build up of starch in roots is likely to help in deciding the optimum time of pruning in N.E. India. The flushing pattern, crop distribution and direction of movement of assimilates are inter related which is depicted in Fig. 5.03.

Table 5.05. *Content of starch in roots as per cent on dry weight basis during the winter months 1980-81.*

Months	Oct.	Nov.	Dec.	Jan.	Feb
Starch %	10	14	17	17	21

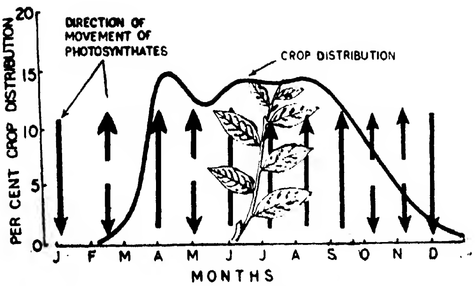


Fig 5.03 Movement of photosynthates and crop distribution in tea.

Studies on Stomatal Behaviour in Tea:

As a prelude to define the parameters for drought tolerance in tea, stomatal behaviour of tea leaves in a few TV clones was studied using a LI-COR diffusive resistance Autoporometer. Diffusive resistance of stomates is a measure of resistance for the exchange of gas and water vapour through the stomatal pores. Hence the sotmatal diffusive resistance is inversely proportional to the degree of stomatal opening and rate of transpiration.

Two preliminary experiments were conducted to investigate the stomatal behaviour of leaves at different layers of the canopy of plucked tea bushes and six successive positions of an unplucked shoot.

1. Stomatal opening as influenced by leaf position in the canopy

Stomatal diffusive resistance of mature leaves on the surface, 10 cm and 20 cm deep in the canopy of mature plucked bushes was measured at intervals of two hours from 8.00 a.m. till 4.00 p.m. on a more or less clear day during the month of July. (Table 5.06).

Table 5.06. *Effect of leaf position in the canopy on stom[illegible] sp[illegible]e expressed as diffusive resistance in sec. (2r[illegible] 1980).*

Clone	Position	8 A.M.	10 A.M.	12 N	2 P.M.	4 P.M.	Mean
TV1	Surface	4.50	4.22	4.45	6.39	10.25	5.96
	Middle	6.43	11.55	7.40	12.45	21.52	11.87
	Bottom	13.02	14.22	9.48	14.10	18.26	13.82
	Mean	7.98	10.00	7.11	10.98	16 68	10.55
TV2	Surface	4.86	4.06	4.52	5.42	6.66	5.10
	Middle	7.59	9.07	8.24	11.86	14.01	10.16
	Bottom	8.98	13.49	9.48	17.78	15.54	13.05
	Mean	7.14	8.87	7.41	11.69	12.08	9.44

LSD at 5% level for
Clone 0.389
Position -- 0.360
Time == 0.339

At the beginning two clones TVI and TV2 were selected for the study of which TV1 is known to be drought tolerant while TV2 is susceptible to drought. Preliminary observations as indicated by the stomatal diffusive resistance reveal that :

(i) The stomates of the leaves in the surface of the canopy were more open than those of the leaves in the deeper layers, light being the limiting factor for the leaves in the lower layers.

(ii) During the morning hours, when both the temperature and light were favourable, the stomates in the surface layer were fully open.

(iii) The stomates closed gradually after 2.00 P.M. with the decreasing light intensity and ambient temperature.

(iv) Comparatively higher resistance to water loss in TV1 than TV2 in respective canopy layers and at different hours of the day was observed and may be attributed to its better drought tolerance than TV2.

2. Stomatal opening as influenced by leaf age

Stomatal resistance was measured on six successive leaves on growing unplucked shoots of field grown TV9

Table 5.07. *Effect of leaf age on stomatal response expressed as diffusive resistance in seconds.*

Position / Time	1st leaf	2nd leaf	3rd leaf	4th leaf	5th leaf	6th leaf	Mean
9 A.M.	10.81	8.76	6.84	6.41	6.37	6.23	7.58
11 A.M.	9.43	7.06	6.41	6.49	6.78	6.68	7.14
1 P.M.	9.47	7.68	7.03	7.11	7.38	7.55	7.77
3. P.M.	10.77	9.23	9.01	8.17	8.09	7.92	8.86
Mean	10.22	8.18	7.32	7.04	7.15	7.11	7.84

L.S.D. at 5% level for
Position = 0.238
Time = 0.277

bush at an interval of two hours from 9.00 a.m. to 3.00 p.m. in the month of February (Table 5.07). Care was taken to eliminate the effect of shade on the lower leaves.

The preliminary results of the investigation show that

(i) The first and second leaves exhibited higher diffusive resistance than the lower leaves.

(ii) The lower leaves did not show any significar differences in the leaf diffusive resistance.

(iii) The stomates in the upper as well as lower leave showed a tendency for closure due to higher ligh intensity (1860 μES $^{-1}$ M $^{-2}$)and temperatur (38°C) as the day advanced.

The stomatal behaviour of leaves in response t changing environment may serve as a criterion to scree the tea plants for drought tolerance. However, furthe studies are in progress for confirmation.

Entomology

Highlights

At 25°C and 80% R.H. ovipositing response of scarlet te was more on TV13 than on the other clones examined. evious observation of rapid build up of red spider and scarlet te associated with foliar application of zinc and other micro-trients was confirmed. Soil topography appears to influence mite activities on tea in Cachar. Thrips incidence was sig-ficantly less on young tea of less than 5 years than on old tea. onitoring through light traps revealed four complete and one rtial brood of red slug caterpillar in Dooars. Polyphenol ntent increased in tea seedling infested with root-knot nema-le than in noninfested seedlings. Biology of a new shade t pest has been worked out. A new synthetic pyrethroid ectively controlled red spider. Two applications of insecti-les at 10 days interval prevented resurgence of thrips for 15 eks. Mortality of thrips increased marginally when be-les spraying on foliage, insecticides were placed in soil and bush frame. Some granular pesticides were evaluated ainst red spider and termite on tea.

MITE PESTS

lonal variability to infestation by Pink mite, *aphylla theae* **(Keifer)**

The responses of Tocklai clones TV1-TV7 to pink ite were evaluated in the laboratory at 20°C : 78-80% .H. using the leaf-disc method. The technique in-lves maintenance of freshly laid eggs on leaf discs iameter 25 mm) of each clone in petridishes kept moist ith wet filter paper and cotton wool. The eggs on e leaf discs were examined for 12 consecutive days 24 hour intervals to record the number of eggs hat-ed. After 12 days the eggs were presumed to have rished.

The larvae emerging out of these eggs were traced the development of adult stage by recording the du-tion of the larval and nymphal stages. Irrespective of e clones, the eggs hatched within 6-7 days (Fig 6.01) ter being laid; maximum number of eggs hatched

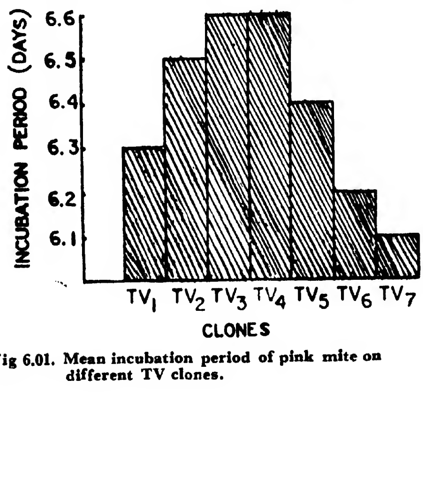


Fig 6.01. Mean incubation period of pink mite on different TV clones.

(88.9%) on TV2, the minimum being (78.6%) on TV5 under comparable conditions. The duration of larval and nymphal stages were nearly the same on all the clones (Fig 6.02).

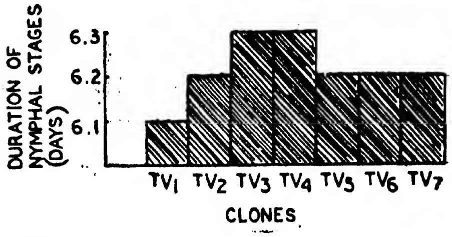


Fig 6.02. Mean duration of development stages of pink mite on some TV clones

Scarlet mite, *Brevipalpus phoenicis* **(Geijskes): fecundity on different clones**

Analysis of ovipositing response of scarlet mite on Tocklai clones, TV11 to TV20, at 25°C, 80% R.H. using the leaf disc method was made. Three leaf discs of each clone with one adult fecund female on each were taken for the study. Each series was examined at 24 hours intervals for 45 days to record the number of eggs laid.

Oviposition period varied between 19 and 28 days on different clones : the longest period being on TV13 and TV16, the shortest on TV19. Maximum number of eggs (16 per female) were laid on TV13 and the least number (3) were laid on TV19 (Fig 6.03). There was a positive correlation between the oviposition period and the number of eggs laid (P=0.05).

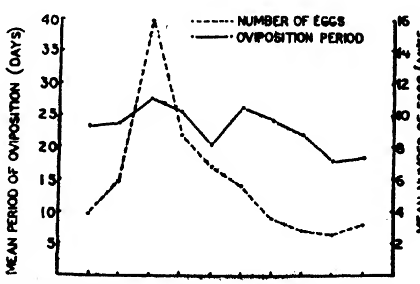


Fig 6.03. Ovipositing responses of scarlet mite on some TV clones.

Effects of foliar application of micronutrients on mite incidence in tea

Sampling of tea leaves for mites were made from plots treated differentially with different formulations of micronutrients (Ann. Rep. 1978-79, p 21). 20 leaves from each of 16 plots were sampled at random at bi-

monthly intervals to record the number of red spiders and scarlet mites.

By a reference to the control series, i.e. plots treated with water, as the base (Fig 6.04) it would appear that red spider population was at its maxima in the plots trea-

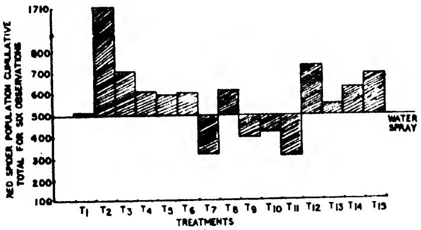


Fig 6·04. Effect of micronutrients on population build up of red spider on tea.

ted with zinc sulphate (T2 in the figure). The population levels of the mite in plots treated with boric acid (T3), and combined treatment of boric acid, zinc sulphate, magnesium sulphate and manganese sulphate (T12), were nearly at the same level as in the untreated series (T15). With chelated zinc treatment (T1), the population level was nearly the same as in water treated plots. Under treatment of magnesium sulphate (T4), manganese sulphate (T5) and molybdic acid (T6), the mite was in the same level as in plots having combined treatments with boric acid, magnesium sulphate, manganese sulphate and molybdic acid (T8). Red spider population was relatively on the negative side in plots treated with various other combinations of these nutrients. Clearly, zinc sulphate by itself may induce rapid build up of red spider populations, though in combination with some of the micronutrients it could inhibit rapid growth of mite population.

In case of scarlet mite, zinc sulphate did induce rapid multiplication by the mite, though with other micronutrients, singly or in combinations, there was no well marked response (Fig 6.05).

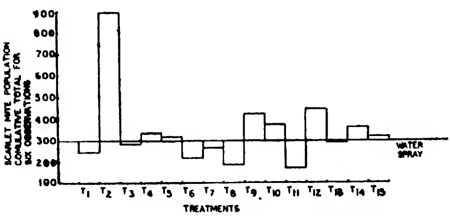


Fig 6.05. Effects of micronutrients on population build up of scarlet mite on tea.

Herbicidal application : effects on population of red spider on tea

Monthly sampling of red spider populations in the permanent herbicides treated areas (Borbhetta) was done during April-October. Red spider population varied significantly in herbicides treated plots (Table 6.01), the maximum being on plots under 2,4-D followed by cheeling, and the minimum under MSMA treatment with manual control. The reasons are not immediately clear, it is likely that the variation in red spider population might be at least partly due to the residual population of mite on weed hosts

Table 6.01. *Incidence of red spider in herbicide treated plots at Borbhetta (average of ten plants).*

Herbicidal treatmens	Cumulative population for seven months
1. Cheeling followed by cheeling	46.6
2. 2,4-D followed by Manual weeding	89.7
3. 2,4-D followed by Paraquat	68.9
4. Paraquat followed by Manual weeding	52.6
5. Paraquat followed by 2,4-D	52.4
6. Dalapon followed by Manual weeding	57.6
7. Dalapon followed by 2,4-D/Paraquat	39.7
8. MSMA followed by Manual weeding	12.8
9. MSMA followed by 2,4-D/Paraquat	48.5
10. Glyphosate followed by Manual weeding	66.1
11. Glyphosate followed by 2,4-D	61.7
12. Simazine followed by Manual weeding	79.1
13. Simazine followed by Paraquat	80.2
14. Diuron followed by Manual weeding	42.2
15. Diuron followed by Paraquat	58.5
L.S.D. (P 0.05)	15.29
C.V.%	50.74

SOIL BORNE PEST

Termite biology

Possible effect of soil topography on distribution of termites, *Microcerotermes* sp. and *Odontotermes* sp. was assessed in the tea growing conditions of Cachar. The degree of termite damage was quantified on tea planted on northern and southern slopes of tillahs under otherwise existing comparable conditions. By and large termite activity, as measured from the degree of damage, was more on tea located on the southern slopes. The lowest degree of attack on the southern slope was significantly more than the maxima on the northern slope (Fig 6.06). Termite activities are normally at optima

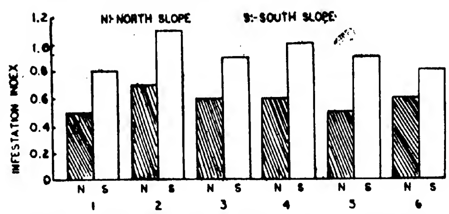


Fig 6.06. Effects of soil topography on termite attack on tea (Numbers on the X-axis denote observation).

during winter when the southern slope receives more sunlight. Though the daily sunlight hours in northern slopes are more in summer than in winter, the damage due to termite was less possibly because of their reduced matabolic activity in summer. However, further ob-

servations would be necessary before any generalisation could be made.

The susceptibility of tea of different age-groups (<5years, 5-20 years and >20 years) was assessed from the degree and magnitude of *Odontotermes* attack. Although in each case the damage symptoms were Cumulative, the damage level increased with the age of the plants. Thus, notwithstanding a marked deviation from the expected linear relationship, the damage on tea less than 5 years old was comparatively less than those on 20 years old tea (Fig 6.07).

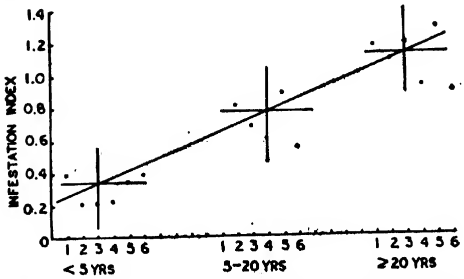


Fig 6.07. Termite damage on tea plants of different age groups (Numbers on the X-axis denote observation).

SAP FEEDERS

Seasonal incidence of thrips and jassid on clones

Seasonal incidence of thrips *Taeniothrips setiventris* (Bagnall) and jassid *Empoasca flavescens* Fab. on clones TV1 to TV19 was assessed continuously for seven months (April-October). Populations of thrips and jassid were on increase from April, peaked in July, declined thereafter to a low level in October. The clones varied significantly in their host specific responses to these two pests. TV11 and TV1 were highly susceptible to thrips and jassid respectively; within a limit TV8 was resistant to thrips and TV2 to jassid (Table 6.02).

Table 6.02. *Incidence of Thrips and Jassid on clones TV1-TV19 (Population on 10 shoots per plot).*

Clone		Population of thrips	Population of Jassid
		(Cumulative for seven months)	
TV1	—	108.8	50.6
TV2	—	62.1	16.3
TV3	—	64.5	17.8
TV4	—	39.8	25.8
TV5	—	66.5	18.3
TV6	—	31.5	26.6
TV7	—	38.1	37.3
TV8	—	17.3	47.2
TV9	—	22.1	39.9
TV10	—	72.4	33.8
TV11	—	117.5	17.8
TV12	—	30.2	22.7
TV13	—	28.9	22.6
TV14	—	38.7	26.0
TV15	—	33.6	31.1
TV16	—	32.4	17.5
TV17	—	27.3	25.5
TV18	—	69.5	35.7
TV19	—	66.3	47.3
L.S.D. (P=0.05)		12.68	9.39
C.V.%		46.63	60.81

The effect of plant-age on the incidence of thrips was evaluated on 19 clones (TV1-TV19) which were sampled continuously for seven months. The plants were grouped as "less than five years" and "more than five years". Ten shoots from each of the 19 clones ($19 \times 10 = 190$ shoots) were examined each month before standard plucking i.e. one sample of ten shoots of one clone once a month. In general, the level of incidence increased significantly with the age of the plants ($P = 0.05$).

Scale insects

The effects of parasites and predators on black scale *Chrysomphalus ficus* Ashm, a pest of tea, were evaluated during July to January. Every month 50 leaves sampled randomly, were examined for the numbers of live scales and scales damaged by parasites and predators. The increase in scale population during July to September was closely followed by the activities of its natural enemies, manifest in the number of affected scales, which possibly regulated scale population within a limit. When, however, there was a decline in the activities of natural enemies in October, there was a concomitant increase in scale population, that continued till November. In the next phase, with the resurgence of natural enemies in December and January a sharp decline in scale population was observed. It is presumed that increased activities of natural enemies might have contributed to such decline in scale population. (Fig 6.08).

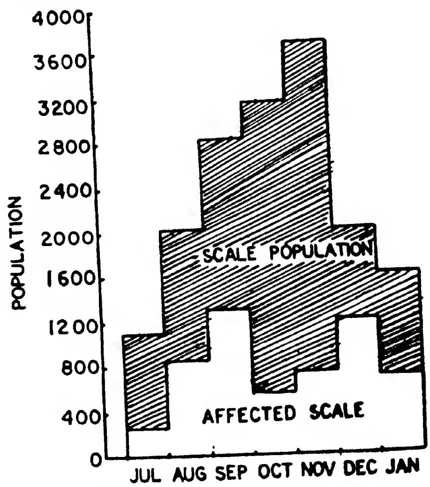


Fig 6.08. Effects of natural enemies assessed from the number of affected scale on population fluctuation of black scale.

TEA DEFOLIATORS

Red slug caterpilar, *Eterusia magnifica* Butl

Preliminary studies on bionomics of red slug caterpillar show that the eggs hatch in about a weeks time

in May-June. The durations of 1st, 2nd and 3rd instars were 3, 6 and 11 days respectively : but the remaining two instars had heavy mortality due to bacterial infection.

Monitoring of moths with light traps together with field sampling of caterpillars indicate four complete and one partial generations in the Dooars. The durations of the generations are shown in (Fig 6.09.)

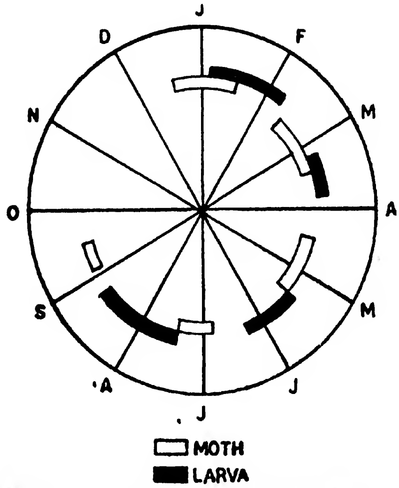


Fig 6.09. Occurrence of different generations of red slug in the Dooars.

SHADE TREE PESTS

Studies on biology of a leaf roller

A new pest, *Dichomeris ianthes* Meyr. (Lepidoptera : Gelachidae), was recorded causing severe damage to *Indigofera teysmanii* Miq. They feed on the foliage and in the precess roll the leaves like sandwiches.

The life-cycle of this pest was completed in the laboratory in 23 days on an average. The incubation, larval and pupal periods were 4, 12-14 and 2-4 days, respectively.

NEMATODES

Susceptibilities of the seedlings of different tea seed stocks to *Meloidogyne incognita* (Kofoid & White) Chitwood

Seedlings of stock 461, 462, 463, 464, 491 and 493 were raised in steam sterilised soil in earthen pots. One month old seedling of each stock was inoculated with 500 freshly hatched larvae of *M. incognita*. Each stock was replicated five times. Sixty days after the inoculation the seedlings were uprooted to record the number of galls and number of egg masses per plant. The number of galls per plant was high in stocks 462, 463 and 464 and low in stocks 491 and 493, while stock 461 occupied an intermediate position (Table 6.03). Inspite of this variation, the number of egg masses on the roots of the seed stocks did not vary significantly.

Table 6.03. *Relative susceptibilities of tea seed stocks to* Meloidogyne incognita *chitwood.*

Seed stock.	Number of galls per plant	Number of egg masses per plant
461	19.33	12.33
462	41.00	42.67
463	44.33	56.00
464	43.00	44.33
491	10.67	2.33
493	11.00	6.33
L.S.D. (P=0.05)	29.90	N.S.
C.V.%	38.98	

Effects of herbicides on nematode population

Soils from the permanent herbicide plots at Borbhetta were sampled for estimation of nematode populations. Comparable samples were drawn from untreated areas. In general, nematode populations in herbicide treated plots from July 1979 to October 1980 was lower than in untreated plots which may be attributed to elimination of weed hosts of the nematodes by application of herbicides. The reasons for sudden rise of nematode population in treated plots from December 1980 to February 1981, as opposed to population in control are not immediately clear (Fig 6.10).

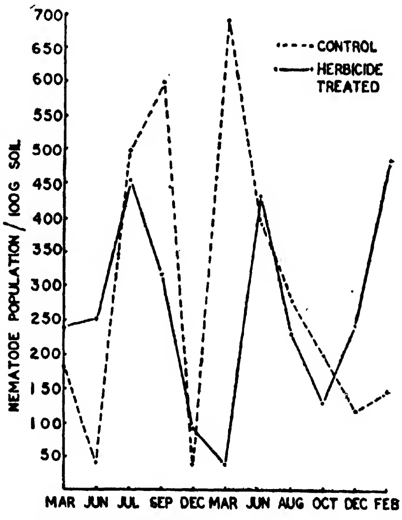


Fig. 6.10. Population fluctuations of nematodes in herbicide treated and untreated plots.

Polyphenol contents of tea plants in relation to root-knot infestation

Five plants each of 1-3 months old and just sprouted seedlings of stock 462, 463, 464, 491 and 493 (considered good hosts of root-knot nematode) and 5, 6, 7 and 9 months old TV18 (considered bad host) plants were inoculated with 500 larvae of *Meloidogyne incognita*

Chitwood and an equal number of plants were kept uninoculated. Sixty days after the inoculation, each plant was uprooted, scored for nematode infestation, and then the whole plant was oven dried at 80°C. Total polyphenols in the dried plant material was estimated by the standard Lowenthal's method. As with the seedlings of stock 449 reported earlier (Ann. Rep. 1979-80 page 57), polyphenol content in the present set of seedlings increased with age, being more in non-infested seedlings. However, unlike seedlings, in clone TV18 polyphenol content increased following inoculation, i.e. the situation was reverse to that of the seedlings (Fig 6.11).

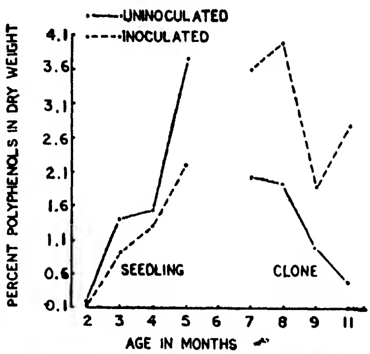


Fig 6.11. Polyphenols in root-knot infested and non-infested tea clones and seedlings of varying ages

The results tend to suggest that infestation of root-knot nematodes may have a bearing on the synthesis of polyphenol in young tea plants (upto 11 months old). While in susceptible plants (seedlings) it tends to retard the process, in less susceptible plants (clone) it induces polyphenol synthesis.

Effects of lights of different wave lengths on nematode extraction

The effect of artificial light of different wave lengths on extraction efficiency of root-knot nematodes by modified Baerman Funnel, earlier carried out at 25°-28°C (Ann. Rep. 1979-80, p. 57) was evaluated this year within a temperature range of 28°—31°C. The rate of extraction was similar to that obtained at the lower temperature range of 25°—28°C, thus suggesting that ambient temperature possibly had no significant influence on extraction efficiency by modified Baerman Funnel.

Pathogenecity of *Pratylenchus* sp. on tea

Two months old potted plant of stock 461 inoculated with 250 *Pratylenchus* sp. per plant, showed no symptoms of infestation in the roots even 60 days after the initial inoculation. Further investigation is in progress.

EVALUATION OF PESTICIDES

Toxicological studies with new insecticides

New commercial formulations of Monocrotophos 40 WSC, Phosalone 35 EC, Chlorpyriphos 20 EC, Hildan 35 EC, Endosulfan 35 EC, Monocil 40 EC and Lebaycid 1000 E were evaluated for their bio-effectiveness against red-slug caterpillars (*Eterusia magnifica* Butl.) These insecticides were topically applied on full grown caterpillars in petridishes by Potter's tower with a pre-calculated deposit of 0.2 mg/sq.cm. of the arena. The cumulative mortality after 96 hours of the insecticidal exposures, were 88%, 55%, 100%, 88%, 66%, 100% and 66% respectively. The caterpillars surviving insecticidal treatments pupated earlier than the untreated caterpillars, but no moths emerged from cocoons formed by insecticide treated caterpillars.

New synthetic pyrethroid acaricide

Laboratory evaluation of the efficacy of Fenpropathrin 20 EC, against red spider was carried out at dilutions 1:2000 (0.01% a.i.), 1:4000 (0.005% a.i.), 1:8000 (0.002% a.i.) and at 1:16000 (0.001% a.i.). Except at 1:16000 dilution a 100% mortality of active stages of the mite was achieved within 24 hours after the acaricidal treatments. While at a dilution of 1:16000 the mortality during the same period was in the region of 80%.

Evaluation of Fenpropathrin 20 EC was also carried out against field infestations of red spider, using toxic strengths of 0.02%, 0.01%, 0.005%, 0.002% in dilutions of 1: 1000, 1: 2000, 1: 4000 and 1: 8000 respectively. The acaricidal solutions were applied with a low volume sprayer fitted with a solid cone nozzle having 75° spray angle and a discharge rate of 450 ml per minute The acaricide at all toxic levels except at 0.002% gave 100% mortality of red spider within 24 hours after application. At 0.002% level the initial mortality was 80% but after 48 hours the cumulative mortality recorded was as high as 96%.

Red spider control trial

Granular insecticide Temik 10 G along with synthetic pyrethroid Fenpropathrin 20 EC, new acaricides Peropal 25 WP, Plictran 50 WP and new commercial formulations of Dicofol 18.5 EC (Hilfol old and Hilfol new, Bangmite), Tetradifon 8 EC (Tetratul) and Ethion 50 EC (Tafethion) were evaluated in a field trial for their acaricidal efficacies against red spider. Tedion V-18 EC was used as a standard acaricide for comparison. The acaricides were applied with a high volume sprayer, the dilutions at which each acaricide was used are given in Table 6.04. Temik 10 G was applied onto the soil round the collar of the plants. Within three days after application significant control with all the acaricides was obtained. The reduction in red spider population which varied from 83-96% within three days, increases upto 99% within a month Initially Temik 10 G gave

Table 6.04. *Comparative bio-efficacies of some new acaricides against red spider* (Mean population of 50 leaves)

Treatments	Rate of dilution	Per cent concentration (a.i.)	Pre-treatment population	Post treatment observation: 3 day Mean population	7 days Mean population	14 days Mean population	1 month Mean population
Temik 10 G	10g/bush	0.1	529.67	325.00	283.67	223.67	4.67
Peropal 25 WP	1:400	0.25	328.00	21.33	25.00	30.67	20.33
Bangmite 18.5 EC	1:400	0.185	467.00	48.67	20.00	93.33	9.00
Plictran 50 WP	1:400	0.5	419.00	50.67	31.00	32.00	14.67
Ethion 50 EC	1:400	0.5	370.67	14.33	13.00	8.00	4.33
Tetratul 8 EC	1:400	0.02	478.33	29.33	7.00	25.67	24.00
Tafethion 50 EC	1:400	0.5	525.00	39.33	13.00	5.33	7.00
Hilfol (old) 18.5 EC	1:400	0.185	657.67	116.00	47.33	8.00	4.33
Hilfol (new) 18.5 EC	1:400	0.185	609.33	90.00	32.67	16.33	20.00
Phenpropathrin 20 EC	1:1000	0.02	582.00	24.67	6.00	1.00	2.00
Phenpropathrin 20 EC	1:5000	0.004	574.33	26.00	18.33	2.33	7.00
Phenpropathrin 20 EC	1:10,000	0.002	582.67	23.33	24.67	8.33	10.00
Tedion V-18 EC	1:400	0.02	507.00	37.33	52.67	35.33	71.00
Control			604.67	620.67	606.33	494.33	441.33

about 38% reduction of red spider population. It may be mentioned here that in order to make the analysis satistically valid, the original data (X) has been transformed to log (x+1) and the conclusions have been drawn on the analysis of transformed data.

Granular and dust formulation of insecticides against termites

A series of field trials were conducted in Assam and Cachar for the control of both live-wood (*Microcerotermes* sp.) and dry-wood (*Odontotermes* sp.) termites on young tea using granular, emulsifiable and dust formulations. Comparative efficacies of Aldicarb 10 G, Carbofuran 3 G, Oftanol 5 G, Thiodan 4% dust, Volaton 500 EC and Thiodan 35 EC were assessed. The three granular insecticides were applied at the rate of 10 g per plant around the collar. Thiodan 4% dust was applied around the collar at the rate of 5 g per plant. Volaton 500 EC and Thiodan 35 EC were sprayed with high volume sprayer on the bush frame and on the soil around the collar of infested plants each at a constant dilution of 1 part in 300 parts of water at the rate of 5 l/ha and 10 l/ha respectively. The degree of termite infestation, as assessed by the extent of fresh earth-runs made by termite activities on bush frame (Table 5) was significantly lower in all the treated plots compared to untreated plots. All these formulations were equitoxic to both the termite species.

Aldicarb 10 G, Phorate 10 G and Carbofuran 3 G along with Thiodan 35 EC as a standard were also evaluated in a trial for termite control on old tea. The granules were applied at the rate of 10 g and 5 g per plant on the soil around the collar. Long term observations show (Table 6.06) that Aldicarb 10 G, Carbofuran 3 G and Phorate 10 G even at 5 g per plant gave an optimal control.

Table 6.05. *Comparative efficacies of dust and granular formulations of insecticides for control of termites on young tea.*

Treatments	Rate of application	Mean degree of infestation per bush (pre-treatment)	Observation after one year: Mean degree of infestation per bush	% reduction over control
Aldicrab 10 G (Temik 10 g)	10 g per plant	0.75	0.26	54.22
Carbofuran 3 G (Furadan 3G)	10 g per plant	1.14	0.22	61.26
Thiodan 35 EC	10 l/ha	0.95	0.09	84.50
Oftanol 5% G	10 g per plant	0.91	0.25	56.34
Volaton 500 EC	5 l/ha	0.80	0.21	63.38
Thiodan 4% Dust	50 kg/ha	0.96	0.12	78.87
Control	—	1.04	0.57	
L S D (P = 0.05)		0.06	0.27	
C.V. %		17.43	76.04	

Table 6.06. *Comparative efficacies of granular insecticides for control of termites on old tea.*

Treatments	Rate of application	Mean degree of infestation	
		Pre-treatment	After one year
Aldicarb 10 G	5 g/plant	1.03	0.37
Aldicarb 10 G	10 g/plant	1.16	0.10
Phorate 10 G	5 g/plant	1.03	0.43
Phorate 10 G	10 g/plant	1.23	0.17
Carbofuran 3 G	5 g/plant	0.90	0.33
Carbofuran 3 G	10 g/plant	1.63	0.07
Thiodan 35 EC	250 ml/plant at 1 : 300	1.00	0.37
Control		1.23	1.07
L.S.D. (P=0.05)		N.S.	0.09
C.V.%			27.78

COCKCHAFER CONTROL TRIAL

Laboratory trial

Ekalux 25 EC, Endocel 35 EC, Thiodan 35 EC, Carbofuran 3 G and Phorate 10 G were applied to soil in green house bench having a population of about 15 cockchafer grubs per 900 sq cm area. EC formulations were applied at 1 in 300 parts and granular formulations at 5 g per 900 sq cm area. 100% mortality of the grubs was obtained with Thiodan 35 EC, Carbofuran 3 G and Phorate 10 G within three weeks after application; the mortality rate was slightly less with other chemicals.

Field trial

Ekalux 25 EC, Endocel 35 EC, Elsan 50 EC, Phorate 10 G and Carbofuran 3 G were applied against cockchafer grub in an area planted with young TV9 plants. The emulsifiable formulations were applied at 1 part in 300 parts of water by volume except with Endocel 35 EC which was applied at 1:500 dilution. 250 ml of the spray fluid was deposited on the soil around the collar of each plant. The granular formulations, applied to the soil around the collar of each plant, were forked into the soil which was lightly drenched with water after application. Compared to untreated areas significant reduction in mortality percentage of the plants was obtained within five weeks in areas treated with the insecticides; the granular insecticides gave the best control of the grubs (Table 6.07). However, at nine weeks after the insecticidal application the mortality rate of the plants slightly increased thereby indicating that the insecticides failed to provide prolonged protection against the grubs.

Table 6.07. *Bioefficacies of different granular and emulsifiable formulations of insecticides against cockchafer. Percentage mortality of plants.*
(Mean of 30 plants)

Treatments	Rate of application per plant	Pre-treatment	Observation after 5 weeks	Observation after 9 weeks
Phorate 10 G	5 g	15.33	7.77	11.10
Carbofuran 3 G	5 g	6.66	5.57	8.90
Ekalux 25 EC	250 ml at 1:300	26.66	15.53	18.97
Elsan 50 EC	250 ml at 1:300	23.33	18.87	24.47
Endocel 35 EC	250 ml at 1:300	30.00	21.10	24.47
Endocel 35 EC	250 ml at 1:500	15.56	25.57	27.77
Control		13.33	38.87	38.87
L.S.D. (P=0.05)		12.16	7.19	6.36
C.V. %		36.40	21.30	16.20

Red slug control trial

Synthetic pyrethroids Decis 2.8 EC, Permasect 25 EC, Permethrin 10 EC and Sumicidin 20 EC and conventional insecticides Accothion 50 EC, Ekalux 25 EC along with Thiodan 35 EC as a standard chemical were used in control trial against field infestation of red slug caterpillar on tea. The dilution rates of the insecticides, sprayed with a low volume sprayer, are given in Table 6.08. Significant control of the caterpillars were obtained within 48 hours after treatments with all the insecticides; the efficacy of Accothion 50 EC was however lower at 48 hours. The level of control obtained within 48 hours remained almost the same after 7 days.

Table 6.08. *Comparative efficacies of insecticidal treatments for control of red slug caterpillar*
(Mean population of caterpillars on 30 bushes)

Insecticidal treatment	Rate of dilution	Pre-treatment population	Population after 48 hours	Population after 7 days
Decis 2.8 EC	1:4000	32.00	2.33	3.00
Permasect 25 EC	1:4000	26.00	2.00	2.67
Permethrin 10 EC	1:4000	26.00	2.00	2.33
Sumicidin 20 EC	1:4000	21.67	2.33	3.00
Accothion 50 EC	1:200	30.00	5.33	4.33
Ekalux 25 EC	1:200	25.67	0.67	1.67
Thiodan 35 EC	1:200	27.00	2.67	4.33
Control	—	23.67	14.67	14.67
L.S.D. (P 0.05)		N.S.	1.92	1.42
C. V. %			27.25	18.00

THRIPS CONTROL

Residual effect of insecticides

To evaluate the residual effects of insecticides on thrips, *Scirtothrips dorsalis* Hood, both synthetic pyrethroids and conventional insecticides at varying dilutions were used. These insecticides were applied with low-volume sprayer at different phases of the population growth of the pest.

Decis 2.8 EC, Permasect 25 EC, Permethrin 10 EC and Sumicidin 20 EC along with Nuvacron 40 WSC Ekalux 25 EC and Thiodan 35 EC were sprayed against high incidence of thrips in May. The dilution rates of different insecticides are given in Table 6.09. A second application of the insecticides was made 10 days after the first application, following hard plucking. Population counts of thrips made one week after first spraying and 1, 3 and 15 weeks after second spraying on randomly selected shoots (Table 6.09) show that these insecticides were equally effective at all the dilutions used. Thus at 1:4000 the synthetic pyrethroids were equivalent

Table 6.09. *Residual effects of insecticides on thrips in tea.*
(Mean population per 10 shoots.)

Treatments	Rate of dilution	Pre-treatment population	One week		Second application	One week		3 weeks		15 weeks	
			Population	% reduction		Population	% reduc-tion	Population	% reduction	Population	% reduction
Decis 2.8 EC	1:4000	37.67	3.33	91.16		0.67	98.22	2.67	92.91	3.67	90.26
Permasect 25 EC	1:4000	39.00	2.67	93.15		0.67	98.28	3.33	91.45	3.33	91.46
Permethrin 10 EC	1:4000	37.00	4.67	87.38		0.67	98.10	3.33	91.00	4.67	87.38
Sumicidin 20 EC	1:4000	33.33	5.00	84.10		1.00	97.00	3.33	90.01	5.33	84.00
Nuvacron 40 WSC	1:200	35.33	3.00	91.51		0.67	98.10	2.33	93.40	5.33	84.91
Ekalux 25 EC	1:200	32.67	2.67	91.87		0.67	97.95	2.67	91.83	6.67	79.58
Thiodan 35 EC	1:200	36.33	5.00	86.24		1.69	95.40	6.00	83.48	6.00	83.48
Control		37.33	29.33	21.43		21.33	42.86	20.00	46.42	17.67	52.66
L.S.D. (P = 0.05)		N.S.	1.89			2.11		1.73		1.45	
C.V. %			16.35			36.95		5.29		76.5	

in their efficacies to the organophosphates and organochlorine insecticides at 1: 200. This shows the stronger insecticidal action of synthetic pyrethroids compared to that of conventional insecticides. Curiously, all the insecticides including the synthetic pyrethroids prevented the resurgence of the pest for a period of about 15 weeks after the second application.

Comparative toxicities of different insecticides

The comparative evaluation of the efficacies of organophosphates, organochlorine and synthetic pyrethroids against thrips was also made. The organophosphates used were Nuvacron 40 WSC, Ekalux 25 EC, Ekatin 25 EC, and Cythion 50 EC. Hildan 35 EC (Endosulfan) and Sumicidin 20 EC were the organochlorine and synthetic pyrethroid respectively. These insecticides were applied with a low volume sprayer, thrice at fortnightly intervals. In Ekatin, Hildan and Sumicidin treated plots the initial mortality after first round of treatment was low compared to those obtained with Nuvacron and Ekalux (Table 6.10). However, after the second round of application, the cumulative mortality increased significantly under all treatments. After the third round of treatment the cumulative mortality remained nearly at the same level thus negating the need of a third round of application. Thus two rounds of insecticidal application could be optimal for the control of early season thrips infestation, though this may not ensure against subsequent build up of thrips from migration.

Table 6.10. *Comparative efficacies of different insecticides for control of thrips.*
(Mean population of 15 shoots)

Treatments		Percent concentration (a.i.)	Pre-treatment population	15 days		Second application	15 days		Third application	15 days	
				Population	% reduction		Population	% reduction		Population	% reduction
Nurvacron	1:200	0.200	28.50	4.67	83.53		1.00	96.47		0.67	97.65
Ekalux	1:200	0.125	29.67	5.00	83.15		2.00	93.26		0.67	97.75
Ekatin	1:200	0.125	30.00	10.00	66.67		2.67	91.11		1.67	94.44
Cythion	1:200	0.250	28.00	11.67	58.33		3.00	89.29		1.67	94.05
Hildan	2:100	0.175	30.00	10.00	66.67		2.67	91.11		2.00	93.33
Sumicidin	1:4000	0.005	28.33	12.00	57.65		2.00	92.94		1.33	95.29
Control			31.67	22.67	28.42		18.33	42.11		21.67	31.58
L.S.D. (P = 0.05)			N.S.	6.03			2.49			2.18	
C.V. %				30.29			30.40			29.07	

New organophosphates

Bio-efficacies of some new organophosphates Volaton 500 EC, Nexion 19.5 EC, Lebaycid 1000 EC against thrips were carried out along with Permasect 25 EC and Endosulfan 35 EC. The dilutions at which the insecticides were applied are given in Table 6.11. A second round of application was made 7 days after the first as prophylaxis against the emerging generation of thrips. Samples drawn seven days after the first treatment showed complete control of thrips.

Subsequent observation showed that the second application kept the resurgent thrips population well below the critical level.

Effect of insecticidal placement on thrips control

Although adult thrips mostly abound foliage, part of their life-cycle is spent in the soil around the collar. To optimize control, it was thought desirable to find out if insecticidal treatment of the soil around the collar region and the bush frame, in addition to that of foliage, would improve the overall control in an epidemic situation. Nuvacron 40 WSC (0.2% a.i.), Ekalux 25 EC (0.112%), Cythion 50 EC (0.25%) and Hildan 35 EC (Endosulfan) (0·17%) all at a dilution of 1 part in 200 parts of water were applied selectively to foliage and to foliage plus soil at the same time. Insecticides were applied twice at three weeks intervals. Cumulative mortality, a fortnight after the second round of treatment, shows (Table 6.12) that "foliage, frame + soil treatment" only marginally improved the overall thrips mortality. These insecticides possibly failed to act on the pupae present within the soil, otherwise control would have been still better.

Table 6.11. *Comparative efficacies of new organophosphates for control of thrips.*
(Mean population of 10 shoots.)

Treatments	Rate of Dilution	Percent concentration (a.i.)	Pretreatment population	One week		Second application	One week		Two weeks	
				Population	% reduction		Population	% reduction	Population	% reduction
Permasect 20 EC	1 : 5000	0.005	65.00	0.00	100.00		0.00	100.00	2.67	95.89
Peomasect 20 EC	1 : 10,000	0.0025	109.00	0.00	100.00		0.00	100.00	3.33	87.31
Volaton 500 EC	1 : 00	0.5000	126.33	0.00	100.00		0.00	100.00	3.33	97.36
Nexion 19.5 EC	1 : 400	0.0488	76.67	0.00	100.00		0.33	99.57	0.67	99.12
Lebaycid 1000 EC	1 : 400	0.0200	75.00	0.00	100.00		1.00	98.66	3.67	95.11
Endosulfan 35 EC	1 : 400	0.0875	96.00	0.00	100.00		0.67	99.19	1.00	98.95
Control			109.33	101.33	7.31		102.33	6.40	93.00	14.92
L.S.D. (P=0.05)			12.56	12.21			4.39		3.25	
C.V. %			21.47	49.82			38.86		27.24	

Table 6.12. *Effects of placement of insecticides for thrips control on tea.*
(Mean population of 15 scoots).

Treatments	Site of placement	Dilution	Pre-treatment population	Observation after first spray				Second aplication	Observation after second spray			
				10 days		21 days			10 days		15 days	
				Population	% reduction	Population	% reduction		Population	% reduction	Population	% reduction
Nuvacron 40 WSC	Foliage	1:200	32.33	2.67	91.75	7.67	76.29		2.33	92.78	2.67	91.75
Nuvacron 40 WSC	Foliage, Frame & collar soil	1:200	28.67	2.00	93.02	5.67	80.23		2.33	91.86	2.67	90.70
Ekalux 25 EC	Foliage	1:200	28.67	3.33	88.37	7.33	74.42		2.67	90.70	2.67	90.70
Ekalux 25 EC	Foliage, Frame & collar soil	1:200	29.67	3.00	89.89	6.33	78.65		1.33	95.51	2.00	93.26
Cythion 50 EC	Foliage	1:200	29.33	6.67	77.27	9.33	68.18		3.67	87.50	4.33	85.23
Cythion 50 EC	Foliage, Frame & collar soil	1:200	31.33	3.70	88.30	7.00	77.66		1.67	94.68	2.67	91.49
Hildan 35 EC	Foliage	1:200	27.00	6.33	76.54	11.00	59.29		3.00	88.89	3.00	85.19
Hildan 35 EC	Foliage, Frame & collar soil	1:200	27.67	4.33	84.34	7.00	74.70		2.00	92.77	2.00	92.77
Control			27.00	19.33	28.40	20.00	25.93		14.67	33.33	19.67	27.16
L.S.D. (P=0.05)			N.S.	1.32		2.99			1.63		1.53	
C.V. %				13.86		19.80			23.84		19.20	

CONTROL OF SHADE PESTS

New leaf roller : *Dichomeres ianthes* Meyr

Two field trials for control of the leaf roller on *Indigofera teysmanii* were carried out in different periods of the year, one in April with conventional insecticides and the other in September with synthetic pyrethroids. The insecticides used and their rates of dilutions are given in Table 6.13. Within one month significant control of the caterpillars were obtained with all the insecticides; the best control having been obtained with

Table 6.13 *Comparative bio-efficacies of some insecticides against* Dichomeris ianthes *Meyr. on* Indigofera teysmanii *Miq.*
(Mean population of 15 plants)

Date of application	Treatments	Dilution	Population per plant after one month	% reduction	Population per plant after two months	% reduction
4.4.80	Thiodan 35 EC	1:200	8.67	40.91	6.67	56.52
	Ekalux 25 EC	1:200	7.33	50.00	7.00	54.34
	Sumithion 50 EC	1:200	5.00	65.91	6.67	56.52
	Nuvacron 40 WSC	1:200	4.00	72.72	6.33	58.69
	Furadan 3 G	5 g/plant	3.00	79.54	5.00	67.39
	Furadan 3 G	10 g/plant	2.67	81.81	5.00	69.39
	Control		11.67		15.33	
	L.S.D. (P=0.05)		4.32		4.53	
	C.V. %		37.55		34.37	
10.9.80	Ripcord 10 EC	1:2000	3.67	85.33	9.33	74.77
	Ripcord 10 EC	1:4000	3.67	85.33	9.33	74.77
	Ripcord 10 EC	1:8000	8.33	66.66	9.67	73.87
	Sumicidin 20 EC	1:2000	2.00	93.33	9.67	73.87
	Sumicidin 20 EC	1:4000	2.67	89.33	16.00	56.75
	Sumicidin 20 EC	1:8000	4.33	82.66	22.00	40.54
	Control		25.00	—	37.00	--
	L.S.D. (P=0.05)		2.32	—	3.43	—
	C.V. %		46.12		57.37	

the synthetic pyrethroid Sumicidin 20 EC at 1:2000 dilution. At 2 months after treatment, however, the synthetic pyrethroids generally failed to maintain the same levels of control, though under treatments of the two conventional insecticides, Thiodan 35 EC and Ekalux 25 EC the level of control increased two months after their application.

Pesticide residues

Wet weather residue samples of Dursban 20 EC and Rogor 30 EC were prepared in the laboratory and sent to manufacturing firms for residue estimation.

Quality control of pesticides

14 samples of insecticides and 29 samples of acaricides received from different tea estate were tested in the laboratory for their bio-efficacy and emulsification standards. Seven insecticides and one acaricide were found below standard.

PEST SURVEILLANCE

New pest record

A leaf roller *Dichomeres ianthes* Meyr. (Lepidoptera/Gelichiedae) has been recorded to feed on foliage of *Indigofera leysmanii* Miq.

New records of parasites and predators

A number of parasites and predators, recorded for the first time on pests of tea and shade trees are listed in Table 6.14.

Table 6.14. *New records of parasites and predators of pests of tea and shade trees during 1980-81.*

Name	Order/Family	Host	Locality
Cocophagus sp. lycimnia (Walker) group	Hymenoptera/ Aphelinidae	*Eriochiton theae* (Green)	Darjeeling
Microteres sp.	Hymenoptera/ Encyrtidae	,,	Darjeeling
Cerapterocerοides sp.	Hymenoptera/ Encyrtidae	,,	Darjeeling
Aphytis sp.	Hymenoptera/ Aphelinidae	*Phenacaspis manii* (Green)	Darjeeling
A beetle (undetermined)	Coleoptera/ Coccinellidae	Eggs of *E. theae* (Green)	Darjeeling
Exorista sorbillans Weidman group	Diptera/ Tachinidae	*Eterusia magnifica* Butl.	Dooars
Apanteles sp. *alter* group	Hymenoptera/ Braconidae	,,	Dooars
Oxyopes sp.	Acarina/ Oxiopidae	*Dichomeris ianthes* Meyr	Assam valley
Pronematus sp.	Acarina/ Tydeideae	*Brevipalpus phoenicis* (Geijskes)	Assam valley
Two mite predators (undetermined)	Acarina		Assam valley

ADVISORY SERVICES

Over 1400 soil samples were analysed for eelworm populations of which about 12% samples were found unsuitable because of high eelworm population. One hundred twenty one pest infested samples of tea and ancillary crops received from different member tea estates were examined and control measures suggested thereof.

Head of Entomology Department, Assistant Entomologist and Senior members of the department visited tea estates in different regions in connection with experiments, sudden pest incidence and their control.

Highlights

Control of red rust with copper fungicides indicated a yield increase trend during the first year's treatment on a five year old clonal plantation. High temperature and prolonged light intensity are conducive for sporangial maturity and dehiscence in red rust. 93% Ascospores of Tunstallia aculeata *germinate in Potatoadextrose agar medium amended with carrot extract and tetracycline in the laboratory trials. Endomycorrhizal association showed different degree of colonisation in different clones.*

The agricultural chemicals tried initially depressed the bacteria and actinomycetes but the fungal counts recorded a spurt. The near native status invariably returned in regard to soil microflora by the 15th week.

Fungicides

Evaluation of a wide range of fungicides—metallic, organic, systemic as well as antibiotics—for their efficacy in controlling important diseases of tea like red rust, black rot, blister blight, branch canker and red spot was undertaken in tea districts of Assam and Darjeeling. Observations on seven other formulations, mainly soil fumigants applied against primary root diseases of tea, are continuing.

Red rust

In an attempt to study the factors which cause the inoculum build up (epidemiology), the physiology of sporulation and sporangial development, spore catch studies were made in the past. Spore counts impacted on the coated surfaces were correlated with the prevailing atmospheric conditions like, temperature, humidity, sunshine hours and rainfall. This year studies were made on the organism under controlled laboratory conditions, on samples of diseased twigs collected from the field after development of disease syndrome.

Infected material showing the algal thallus and sporangial initiation as indicated by reddish-brown patches on the stems and etiolation of leaves produced by previous year's infection, were collected and placed in the BOD incubator at different temperatures. Sporangial status and dehiscence were studied after 48 hours at different temperatures. Effect of light intensity on sporulation and sporangia was studied by holding the material at 60 cm distance from four Philips Argenta 100 W bulbs for different periods. When not exposed for light the material was kept in a dark room.

Sporangial maturity and dehiscence are directly influenced by temperature: the higher the temperature, the greater the sporangial dehiscence.

The sporangia even when kept in total darkness matured to a maximum of 32% in 72 hours while exposure to light as shown in Table 7.02 improved the maturity.

Table 7.01. *Effect of temperature for 48 hours on the sporangial maturation and dehiscence of red rust (Total sporangia observed 250).*

Temperature oC	% maturity of sporangia
20	27
25	40
30	73
35	96

Table 7.02. *Effect of light on red rust sporangial maturity after 24, 48 and 72 hours (average of 6 trials with 200 sporangia each trial).*

Maturity after	Light exposure in hours/day of 24 hours	
	Dark (0 hrs.)	4 hours
24 hours	3%	39%
48 hours	21%	73%
72 hours	32%	94%

These results confirm the findings on the spore trappings, correlated with atmospheric conditions. (Annual Report 1967-68.)

Field trials

During the year, experiments on red rust were conducted in two locations. One was a screening trial where new fungicides, a sticker and one antibiotic additive were compared with a standard copper fungicide for their efficacy. The other was to assess the effects of standard fungicide treatment on disease control and yield-benefit evaluation.

Screening trial

One experiment was carried out in a severely infected, 5 year old, hedge-planted TV1 clonal area. Four rounds of spray were given commencing on 13 May 1980; the first two at fortnightly interval and the subsequent ones at monthly interval by hand operated Bakpak sprayers. The experiment had eight treatments including an untreated control. The treatments included four new formulations, one standard fungicide (Blue copper), one sticker Pidivyl and an antibiotic Plantomycin incorporated with standard fungicide. The sticker was used with the fungicide at 1:1 ratio by weight and the antibiotic at 200 ppm. Each treatment was replicated four times in plots of 50 bushes each in two rows of 25 bushes in staggered double hedge plantation. The overall control achieved was determined by assessing visually the degree of incidence of the disease in each bush in a 0-4 scale of severity (0=No infection, 1=mild, 2=moderate, 3=high and 4=severe). The results are given in Table 7.03.

With the exception of Burcop all the formulations produced similar degree of disease control. The performance of the standard fungicide was improved by

Table 7.03. *Degree of red rust infection per plot of 50 bushes each (mean of 4 replication) and per cent improvement of treated plots over control.*

Treatments	Rate of Dilution	Degree of infestation	% improvement over control
1. Elatox	1:400	13.50	65.16
2. Parkens (copper)	1:400	11.75	69.68
3. Macuprax	1:200	11.75	69.68
4. Burcop	1:200	22.75	43.23
5. Blue copper (standard)	1:400	13.50	65.16
6. Blue copper + Pidivyl (1:1)	1:400	9.00	76.77
7. Blue copper + Plantomycin	1:400 200 ppm	10.25	73.55
8. Untreated	—	38.75	—
C.D. at P=0.05	—	8.07	...
C.V.%	-	33.63	—

the addition of the sticker Pidivyl or Plantomycin, though the improvement was not significant.

Effect of red rust control on yield

The second experiment was a study on the effect of control of the disease on yield. This trial was conducted on a double hedge planted, 5 years old clonal tea, showing heavy incidence of red rust. Both the recommended rates of a standard copper fungicide (Blue copper 1:400 & 1:1000) were applied with hand operated Bakpak sprayers to plots of 90 bushes each, in six randomised replicates. There were three treatments including an untreated control. In treatment No. 1 the copper fungicide was applied at 1 in 1000 parts of water for 6 rounds at fortnightly interval beginning 19.5.80, the last round being applied on 6.8.80 while in treatment No. 2 fungicide was used at 1 in 400 parts of water and applied in 4 rounds between 19.5.80. and 6.8.80 the first two rounds at fortnightly interval and subsequent ones at monthly interval. The overall effect of fungicidal application on disease incidence was assessed as usual in 0-4 scale of severity and the results are given in Table 7.04.

Table 7.04. *Degree of infection per plot of 90 bushes (mean of 6 replicates) and per cent improvement of treated plots over control.*

Treatments	Dilution	No. of rounds	Degree of infection	% improvement over control
Blue copper	1:1000	6	73.5	71.01
Blue copper	1:400	4	53.5	78.90
Control (unsprayed)			253.5	—
C.D. at P = 0.05	—	—	35.7	—
C.V. %	—	—	21.88	—

Application of Blue copper at 1:400 and 1:1000 dilutions resulted in highly significant control of the disease. There was, however, no significant difference between the two rates.

The experiment will be continued over a pruning cycle. However, the yields recorded from 24.5.80 to 14.10.80. over 20 plucking rounds are presented in Table 7.05.

Table 7.05. *Yield of green leaf in grams per plot of 90 bushes (from 24.5.80 to 14.10.80.)*

Treatments	Dilution	Yield of green leaf in g
Blue copper	1 : 1000	6688
Blue copper	1 : 400	7132
Control	—	6487
C.V. %	—	7.86

The yield increase of the treated plots has not so far been statistically significant as the treatment affect will take some time to manifest.

Branch canker

(i) The ascospores of the fungus *Tunstaillia aculeata* were grown in artificial medium in Darjeeling and studies on the time required for mature perithecial production was initiated on excised branches incubated at room temperature. *T. aculeata* utilises tea stem as a substrate for formation of perithecia. Under ambient laboratory conditions it took 45 days to produce perithecial masses on tea stem, while it failed to do so in culture medium even after 80 days.

(ii) It was observed that 93% ascospores germinated in 3 days time in potato dextrose agar medium amended with carrot extract and tetracyeline. The spores do not have any particular type of cell that germinate initially, though bipolar germination is more common than unipolar germination.

Black rot

One screening trial with different fungicides was conducted during the season to evaluate their efficacy in controlling black rot. The treatments were the same as in case of the red rust screening trial. In this trial, however, the number of bushes per plot was 30 and there were 4 replications. The bushes were 15 years old, planted in single hedge and carried moderate to severe infection. Two rounds of fungicides were sprayed on 10th and 24th June 1980, at fortnightly interval, and third round was applied nearly three months later on 19th September 1980. The final assessment of the performance of the fungicides was made on 10th October 1980 by recording the degree of disease inci-

Table 7.06. *Degree of incidence of black rot per plot of 30 bushes (mean of 4 replications) and per cent improvement of treated plots over control.*

Treatments	Rate of dilution	Degree of incidence	% reduction over control
Elatox	1:400	13.25	77
Parkens	1:400	20.75	65
Macuprax	1:200	21.25	64
Burcop	1:200	18.50	69
Blue copper	1:400	20.75	65
Blue copper + Pidivyl	1:400 + 1:1	16.50	72
Blue copper + Plantomycin	1:400 + 200 ppm	21.00	64
Control	—	58.75	—
C.D. at P = 0.05	—	12.71	—
C.V. %	—	36.23	—

dence on each bush in 0-4 scale of severity. The results are given in Table 7.06.

All the fungicides tried significantly reduced the disease; there being no significant difference amongst them. Addition of Pidivyl slightly improved the performance of Blue copper, though not manifested at statistically significant level.

Root rots

Root rots have been successfully arrested by fumigation. No death from root disease infection has been recorded from any of the six soil fumigation experiments, the first of which was started seven years ago. A long-term experiment is being initiated on a large scale to study if soil fumigation can replace two year rehabilitation period in replanted teas.

Blister blight

During the year one experiment was laid out in Darjeeling against blister blight. It was a routine trial for screening of fungicidal formulations as in cases of red rust and black rot.

In this trial there were ten treatments including one standard fungicide (Blitox) for comparison and one untreated control. The treatments were applied every week for 5 weeks following plucking to plots of 40 bushes, randomised in 3 replications. The results of the weekly assessments made by counting the number of blisters on the 3rd leaf on samples drawn from bulk pluckings are given in Table 7.07.

The overall estimates show that the performance of Elatox is comparable to that of the standard fungicide Blitox. Of the other new fungicides, Burcop and Macuprax did not provide comparable protection at the dilutions tried.

Table 7.07. *Per cent reduction of blister blight over control following fungicide spray.*

Treatments	Rate/ha	Spraying interval in days	1 week after the 4th round 8.8.80	1 week after the 5th round 16.8.80	2 weeks after the 5th round 22.8.80	Average
1. Blitox	625 g	7	66.41	74.48	73.24	71.38
2. Blitox + Plantomycin	625 g + 200 ppm	7	83.97	80.69	71.29	78.65
3. Elatox	625 g	7	74.81	55.59	73.94	68.11
4. Burcop	1000 g/100 l	7	41.22	54.48	59.15	51.62
5. Burcop	500 g/100 l	7	51.91	49.66	61.27	54.28
6. Macuprax	500 g/100 l	7	31.30	42.07	54.73	42.77
7. Macuprax	250 g/100 l	7	16.03	48.97	22.54	29.18
8. Calixin + Pidivyl	200 ml/ka + 1 : 2.5	14	43.51	48.97	62.68	51.72
9. Blitox + Plantomycin	400 g + 200 ppm	7	78.63	48.97	66.90	64.83
C.D. at P=0.05			35.93	22.82	19.78	
C.V. %			40.92	26.84	25.44	

Red spot disease

Red spot of young tea shoots and to some extent mature leaves have become a matter of concern for some estates in Darjeeling. During the year a control trial was laid out in an estate in the Kurseong area using one Copper fungicide, one systemic fungicide, two antibiotics, one insecticide and an acaricide. Altogether six rounds were applied with hand operated Bakpak sprayers to plots of twenty bushes each, replicated three times. The spray volume was calculated at 300 l/ha per round. The disease intensity was recorded for each individual plot by collecting 100 shoots at random and measuring the degree of incidence in the 0-4 scale of severity. The results assessed one week after the application of the last round are presented in Table 7.08.

Copper fungicide at 1250 g/ha appeared to give better control of the disease. Bavistin, a systemic fungicide, has also effected appreciable reduction of the disease. The degree of amelioration shown by the acaricide and the insecticide indicate the need for an integrated approach to the problem.

Table 7.08. *Effect of different spraying treatments on red spot incidence.*

Treatments	Degree of incidence	%reduction over Control
1. Blitox 625 g/ha	11.00	62.93
2. Blitox 1250 g/ha	7.00	76.41
3. Bavistin 250 g/ha	10.67	64.04
4. Plantomycin 200 ppm/ha	24.33	18.00
5. Blitox 625 g/ha + Agrimycin 200 ppm	13.33	55.07
6. Thiodan 1.25 l/ha	18.67	37.07
7. Thiodan 2.5 l/ha	20.67	30.33
8. Kelthane 1.25 l/ha	24.33	18.00
9. Kelthane 2.5 l/ha	18.00	39.33
10. Control (unsprayed)	29.67	
C.D. at P = 0.05	10.00	
C.V. %	32.8	

Microbiology

Quantitative studies on fungi, bacteria and actinomycetes from herbicide treated plots indicated that though there was an initial spurt of fungal growth and fall in numbers of bacteria and actinomycetes, normal balance returned after 15 weeks following application

of Paraquat, 2,4-D, Dalapon, MSMA, Glyphosate, Simazine and Diuron.

Mycorrhiza

Degree of mycorrhizal colonisation during the dry months of October-December was studied on Tocklai released TV1 to TV9 and TV18, TV19 and TV20. Clones can be grouped as follows on the basis of tea mycorrhizal association :

A. TV2, TV3, TV5, TV6, TV8, TV9, TV19, TV20 25% of the examined roots showed VA mycorrhiza

B. TV1 and TV18—50% -do- -do-

C. TV4 and TV7 —75% -do- -do-

Further work is in progress.

Spore catch studies

These were inconclusive due to frequent closures encountered during the year. Trap at Darjeeling installed at Goomtee T.E. could not be operated due to labour unrest. It will be brought back and installed in Upper Assam on a garden of known blister incidence.

ADVISORY SERVICES

Nearly two hundred samples of diseased tea and ancillary crops were received from member estates for diagnosis, examination and suggesting suitable control measures. Over one hundred and fifty water samples were examined for bacterial contamination and advice. A few fungicide samples kept for long period in storage were also examined for their fitness for use.

Head Mycology Department attended A.S.C. meetings different regions and visited a number of estates. Staff from the department visited some estates in connection with different diseases and their control.

Highlights

To understand the reasons for the failure of tea bushes to respond to increasing doses of fertiliser nitrogen the activity of the enzyme nitrate reductase, NR, in tea roots was studied in bushes receiving 100, 200, and 300 kg N/ha. The activity of NR like the crop yield, major polyphenols, soluble and protein nitrogen in leaf and the quality of made teas, showed a maximum at a fertiliser dose of 200 kg/ha and declined at 300 kg/ha.

Maximum amount of N, P, & K in shoots at six different combinations of potash and phosphorus and at a common dose of nitrogen (135 kg N/ha) was seen at $p_{45}K_{45}$, *where the quality was minimal. Maximum absorption of nutrients was also seen during the rainy season.*

Some of the flavoury constituents were observed to be relatively very high in second flush Darjeeling teas than in the corresponding Assam teas.

Polyphenol oxidase activity was observed to decrease during withering and this may have a direct bearing on the rate of fermentation during manufacture of tea. This loss, however, could be restored by rehydrating the withered leaves.

Diversifying tea utility has made good progress. Three pigments were prepared in large quantities from made teas. These are now being tested for their usefulness as food colours.

BIOCHEMICAL EVALUATION OF TEA QUALITY AS AFFECTED BY AGROTECHNIQUES

Effect of NPK

Earlier study on the effect of P and K fertiliser in different doses (0, 45, 180 kg/ha) revealed that application of P upto 45 kg/hectare has beneficial effect and application of K has somewhat depressing effect on the quality of made teas (Ann. Rep. 1975-76; 1976-77). A more systematic study was conducted with Clone TV2 (DS), (Area B105 having the following doses of P and K superimposed on 135 kg of N per hectare):

Treatment	Level of P & K. kg/ha	
	P_2O_5	K_2O
T_1	0	0
T_2	0	45
T_3	0	90
T_5	45	0
T_6	45	45
T^9	90	0

Plucked shoots were collected through the Agronomy department at fortnightly intervals throughout the season from the different plots and were manufactured by C.T.C. process. The unprocessed tea shoots were analysed for N, P and K contents. The C.T.C. teas were evaluated biochemically as well as by Tea Tasters.

The seasonal average of total N, P and K contents in the different treatments are presented in Table 8.01.

Table 8.01. *Seasonal average (till end of October) content (g/100 g dry wt.) of total N, P and K in tea shoots of Clone TV2 under different levels of PK fertiliser.*

Treatments	% total nitrogen	% P_2O_5	% K_2O
T_1	4.46	0.61	2.28
T_2	4.55	0.65	2.58
T_3	4.66	0.63	2.70
T_5	4.52	0.63	1.96
T_6	4.77	0.74	2.62
T_9	4.59	0.69	2.34

Although the same level of N was applied in all the treatments, the amount of N in tea shoots was minimum in T_1 in which there was no application of P and K, but was maximum in T_6 having $P_{45}K_{45}$, due probably to their synergistic effect.

With increasing dose of K (in T_2 & T_3), the K content of the shoots increased and with it the absorption of N also increased. Increasing dose of P seemed to have similar effect but to a lesser degree. Combination of both P and K along with N (in T_6) increased the content of N, P and K, in the plucked shoots.

Table 8.02 gives the monthly average of N,P and K content of the shoots during the season.

Table 8.02. *Monthwise variation of N, P and K content (% dry wt.) in tea shoots of TV 2 under different levels of PK fertilizers*

Treatments	% Nutrient	June	July	August	Sept.	October
T_1	N	4.39	4.98	5.15	4.13	3.98
	P_2O_5	0.60	0.65	0.61	0.59	0.56
	K_2O	2.10	2.22	2.34	2.40	2.48
T_2	N	4.65	4.97	5.07	4.16	4.14
	P_2O_5	0.60	0.71	0.71	0.60	0.63
	K_2O	2.42	2.57	2.53	2.75	2.75
T_3	N	4.85	5.01	5.16	4.30	4.21
	P_2O_5	0.53	0.75	0.64	0.56	0.66
	K_2O	2.49	2.60	2.72	2.93	2.87
T_5	N	4.46	4.91	5.51	4.22	4.16
	P_2O_5	0.63	0.60	0.61	0.70	0.68
	K_2O	2.01	1.98	2.11	2.20	2.32
T_6	N	4.85	5.25	5.40	4.35	4.31
	P_2O_5	0.70	0.81	0.72	0.74	0.70
	K_2O	2.40	2.56	2.71	2.76	2.79
T_9	N	4.57	5.00	5.22	4.29	4.19
	P_2O_5	0.62	0.80	0.77	0.59	0.66
	K_2O	2.15	2.32	2.49	2.49	2.47

It was observed that in all the treatments, N and P content of the shoots were at a higher level during July and August and declined towards the latter part of the season. The K content continued to increase upto end October.

Table 8.03 gives the seasonal average values for TF, TR content and Tasters valuations of the made teas of different fertilizer treatments.

...rag ...ues over the season for TF, TR content and tasters 'ua'ions of CTC teas of Clone TV2 under different levels , PK.

Treatment	% TF	% TR	TF/TR	Tasters valuation, Rs/kg	
				Calcutta	Tocklai
T_1	2.00	16.58	0.12	21.79	7.44
T_2	1.81	16.21	0 11	21.33	7.25
T_3	1.83	16.86	0.11	20.37	7.28
T_5	1.97	17.00	0.12	21.45	7.25
T_6	1.75	16.59	0.11	20.19	6.56
T_9	1.88	17.54	0.11	20.06	7.17

Treatment T_1 having only N and without P and K had the highest TF content as also TF/TR ratio and fetched the highest price from both the Tasters. With the application of $K(T_2, T_3)$ along with N, the TF content decreased which also lowered the TF/TR ratio. Consequently the valuations also came down. It therefore corroborated our earlier observation on the depressing effect of K on tea quality. Application of P at the rate of 45 kg/ha (T_5) with N had higher TF content compared to application of K (T_2, T_3). It had the same TF/TR ratio as treatment, $T_1(P_0K_0)$. Calcutta Taster rated these teas the second best. Higher dose of P (90 kg/ha) was found to be slightly inferior in both TF content and TF/TR ratio, corroborating our earliet observation. Shoots from T_6 (P_{45}, K_{45}) showed maximum amount of NPK. The corresponding teas had however lowest TF content and considered inferior by Tea Tasters.

The experiments are being continued to study the effect of P & K on quality of both CTC and Orthodox teas.

NITROGEN METABOLISM IN TEA LEAF

Effect of fertilizer nitrogen on various chemical components of tea leaf and roots and on quality of made teas

In the last year various chemical components of shoots and roots were analysed and it was concluded that the poor absorption of fertilizer nitrogen under heavy dose of ammonium sulphate cannot be explained unless the enzyme systems responsible for intake of nitrogen are properly explored (Ann. Sci. Rep. T.R.A.,1979-80). Therefore in the first instance a method of assay of nitrate reductase activity (NRA) in tea roots has been developed. Preliminary study on the NRA in the roots of the bushes of Clone TV9 (Area 8/1 120 cm × 22.5 cm spacing) showed that NRA varied in the roots of bushes receiving 100, 200 and 300 kg N per hectare as ammonium sulphate. The activity was highest in the roots receiving 200 kg N per hectare, which declined in the roots with 300 kg N. A detailed study of NRA at higher nitrogen doses is in progress.

Of the nitrogen fractions, total nitrogen, soluble nitrogen, amide nitrogen and protein nitrogen in the feeder roots increased with the dose of nitrogen (Table 8.04).

Table 8.04. *Effect of fertilizer nitrogen on total nitrogen, soluble nitrogen, amide nitrogen and protein nitrogen in feeder roots of Clone TV9.*

Nitrogen ractions	Concentrations (g/100 g dry root)		
	N_{100}	N_{200}	N_{300}
Total nitrogen	2.02	2.33	2.47
Soluble nitrogen	0.50	0.66	0.68
Amide nitrogen	0.20	0.31	0.33
Protein nitrogen	1.52	1.67	1.79

In view of the fact that polyphenols present in tea leaf are responsible for tea colour and quality, the corresponding tea shoots were analysed for six major polyphenols. Teas were evaluated by Tocklai and Calcutta tasters and also assessed for six major polyphenols. Teas were evaluated by Tocklai and Calcutta tasters and also assessed for theaflavin and thearubigin contents. The results are summarised in Tables 8.05. and 8·06

Table 8.05. *Effect of fertilizer nitrogen (kg/ha) on polyphenols in tea shoots.*

Chemical components	Concentrations (g/100 g dry shoot)		
	N_{100}	N_{200}	N_{300}
(—)—Epigallocatechin	5.34	5.53	5.46
( )—Epigallocatechin gallate	8.79	9.23	8.81
(—)—Epi catechin gallate	2.39	2.53	2.49
(- -)—Epi catechin	1.30	1.34	1.32
Catechin/gallic acid	0.93	0.98	0.92
Theogallin	1.36	1.44	1.31
Total of six polyphenols	20.11	21.05	20.31

Table 8.06. *Effect of fertilizer nitrogen on quality of teas (Clone TV9. Area 8/1).*

	N_{100}	N_{200}	N_{300}
Theaflavins (%)	1.38	1.44	1.51
Thearubigins (%)	16.15	15.99	16.86
TF/TR	0.086	0.090	0.090
Tocklai Taster (Rs/kg)	7.06	7.22	7.22
Calcutta Taster (Rs/kg)	16.76	16.33	16.26

The six major polyphenols changed marginally in the shoots receiving different quantities of nitrogen. Although the quantitative changes were not significant biosynthesis of all the six polyphenols were maximum at 200 kg N/ha. Further increase in the nitrogen dose to 300 kg/ha adversely affected the biosynthesis of polyphenols, particularly of (—)—epigallo catechin gallate. Tocklai tasters preferred teas at these higher doses of nitrogen. However Calcutta tasters had a slight preference for the teas from the bushes receiving 100 kg N/ha.

Further work is in progress to establish the effect of 'N' on quality.

BLACKNESS OF MADE TEA

In C.T.C. manufacture, the shade of the manufactured tea appears more brown than black. In tea trade, however, black shade of tea is preferred to brown shade. In an attempt to retain black shade in C.T.C. teas, experiments were conducted by varying the pro-

cessing conditions. Clone TV1 which is prone to produce brown shade was used in the experiments.

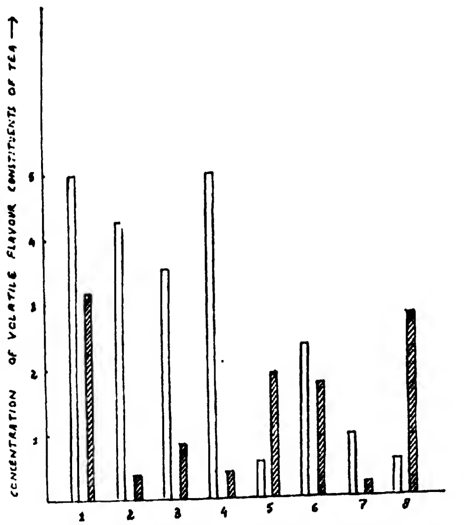
Acceleration of fermentation did not help in producing blacker teas. Subsequently, the rate of fermentation was retarded by giving a hard wither, light roll followed by split C.T.C. For comparison, control samples were manufactured by usual C.T.C. process. Made teas produced by retarding the rate of fermentation were blackish in appearance compared to brown teas of usual C.T.C. but had similar cup characters. Experiments are being continued during 1981.

Investigations on volatile constituents of teas

Some work on the flavoury constituents of Assam teas and their variation with seasons or flushes was reported earlier (Ann. Sci. Rep. 1978-79). A comparative study on flavour constituents of Assam and Darjeeling teas was done.

For the study of flavour second flush teas were estimated for their major volatile constituents. The method of extraction was low temperature steam distillation under vaccum.

Assam teas were found to contain larger amount of phenylacetaldehyde and benzylalcohol. The geraniol content in plains teas was in traces only. However, the amount of some of the flavoury volatile constituents were found to be ten times higher in Darjeeling teas than in Assam teas (Figure 8.01).



1. Linalool Oxide (Furanoid) 2. Linalool 3. Linalool Oxide (Pyranoid) 4. Geraniol 5. Benzyl Alcohol 6. 2-Phenyl Ethanol 7. Hexenol 8. Phenyl Acetaldehyde.

Fig 8.01. Relative concentration of some of the flavoury constituents of Darjeeling and Assam tea.

Futher work on the flavoury constituents is being continued.

EFFECT OF WITHERING ON ENZYME ACTIVITY

Withering of tea shoots causes a depression in the activity of polyphenol oxidase, but the total uptake of oxygen is not affected in withers generally used for black tea manufactures in the plains of N.E. India (Ann.Rep. 1977-78). The oxidase activity and total oxygen uptake as affected by different degree of withering was studied. Tea shoots were physically withered by subjecting to warm (35°-40°C) air blast in a trough and enzyme activity and total oxygen uptake were measured. Data are presented in Table 8.07.

Table 8.07. *Effect of degree of wither on enzyme activity and total oxygen uptake of tea shoots of Clone TV8.*

% Wither	% Moisture	Enzyme activity µl/mg	Total oxygen uptake µl/mg
0 (Fresh leaf)	80.62	12.80	8.24
74	74.23	9.55	7.95
62	69.54	8.99	7.20
52	63.68	8.81	7.08

It appeared that loss of moisture during withering might affect the activity of the enzyme. The total oxygen uptake was also lowered to certain extent by high reduction of moisture of the shoots caused by hard wither, probably due to lowering of the enzyme activity. It was therefore examined whether the activity could be restored by withdrawing the water stress conditions. For this, the withered tea shoots were rehydrated by dipping the stem ends in double distilled water till the wilted shoots became turgid by absorption of water. The enzyme activity and total oxygen uptake of fresh, withered and rehydrated shoots are given in Table 8.08.

Table 8.08. *Enzyme activity and total oxygen uptake of fresh, withered and rehydrated tea shoots of Clone TV5.*

Sample	% Moisture	Enzyme activity µl/mg	Total oxygen uptake µl/mg
Fresh shoots	80.50	13.33	8.17
Withered shoots	69.91	8.17	7.74
Rehydrated withered shoots	79.25	13.88	8.61

Data in the table show that the loss in enzyme activity, due to partial desiccation by withering, can be restored by rehydration of the withered shoots.

The loss of enzyme activity during withering of tea shoots was also varified by C.T.C. manufacture of withered and unwithered fresh shoots. It was observed that in unwithered C.T.C., the production of TF was always higher than in withered C.T.C. which can be attributed to higher enzyme activity of the unwithered fresh shoots. Thus loss of enzyme activity during withering may have a bearing on the rate of fermentation of the tea shoots during manufacture of black tea.

Food Colourants

Tea and tea waste are rich in orange and reddish brown pigments. Extraction of these pigments was done on a laboratory scale to test the suitability of tea pigments as food colourant. Three pigments A, B, and C were isolated. Pigment C was soluble in water. Since any food colourant before being passed for its utility in food industry has to be tested for its toxicity, the pigments isolated from tea have been sent to Indian Toxicological Research Centre (Lucknow) for assessing their biological toxicity.

Advisory

Water samples received from Tea Estates were advised upon their suitability in tea factory.

Kay-bee and N-Foss moisture meters of various estates were standardised and calibrated.

Highlights

Hot Lemon and Hot Spicy teas have been developed by the addition of natural ingredients during the processing of orthodox teas. These teas which can be drunk without milk resulted in increased cuppage.

Cup characters of C.T.C. teas made from jat leaf by mixing with clonal leaf in green leaf stage tended to be equally good if not superior to teas mixed after manufacture.

Blending of clonal tea

The effect on mixing clonal tea with jat tea in different proportions has been under investigation for the past few years. Earlier results were published in the Annual Scientific Reports for 1977-78, (p-67); 1978-79 (p-68) and 1979-80, (p-73).

Taking into consideration the difficulties of mixing teas from jats and clones after manufacture, an attempt was made to investigate the effect of mixing of jat and clonal leaf in the green leaf stage on C.T.C. liquor.

For this experiment, leaf from TV1, TV9 and TV 18 and Betjan jat were withered to about 75% and manufactured by the C.T.C. process. Cup characters of the good quality Betjan jat further improved when 15% withered leaf of clone TV1 was mixed with 85% withered leaf of the jat. Similarly cup characters of the yield clones TV9 and TV18 improved when mixed with 80% withered leaf of the Betjan jat.

Lining material for plywood tea chest

Lining of Biaxially Oriented Polypropylene film under the brand name 'M.M. Wrap' was tested against standard aluminium foil lining in 50 kg plywood tea chest. The interim findings are that it did not impart any taint or caused any adverse effect on the liquor characters of made teas. Moreover, no significant difference was noticeable in the moisture content of teas packed with this and the aluminium foil lining materials. This experiment was started in early July and will be continued for a storage period of one year, after which details of tasters' evaluation, moisture content, biochemical assessment and results of toxicity test and physico-chemical test will be published.

Long term trial with newly approved lining material

A long term trial with newly approved lining materials was conducted with the object of finding out their desirability as lining material for plywood tea chest for a storage period of one and half years. The lining materials were collected randomly from the local market to see their overall performances during the storage period. The materials are : nitrocellulose film, 12 micron metallised polyester film and aluminium foil lining. The Poly-Vinylidene Chloride coated film was not available in the local market when the experiment was started. The experiment was started in the month of July and will be continued for a period of one and half year.

Improvement of clonal C.T.C. leaf appearance

In continuation of the previous findings on improvement of C.T.C. leaf appearance (Ann. Rep. 79-80, p-74) further observations were made on split C.T.C. method of manufacture. The teas made from clones TV1, TV16 and TV17 tended to be a little blacker under this system of manufacture, but the decline in brightness and briskness in cup was quite noticeable.

Other forms of tea

The department initiated development of a new kind of tea termed as 'Hot Lemon Tea' which can be drunk without the addition of milk. Lemon and different types of spicy flavours of natural origin were added during the manufacturing process. These teas have been favourably commented upon by the panel of tasters including overseas tasters. The additional advantage of these orthodox teas is increase in cuppage by 50% more. Further work is proceeding for standardisation and commercialisation of the process.

ASSESSMENT OF CUP CHARACTERS OF CLONES AND STOCKS

Estate clones : In order to assess the quality in cup, leaf samples of 12 estate clones were manufactured throughout the season by orthodox and C.T.C. methods and compared against TV16 as standard. The samples were tasted by the panels of tasters including Tocklai taster. The result showed that eight clones came up well in respect of cup characters. The experiment, however is being continued further.

Biclonal stocks: To help evaluation of the new selection scheme of Nagrakata sub-station, biclonal stocks with TV1 as standard were manufactured by orthodox and C.T.C. methods. Evaluation made by the panels of tasters showed that out of eight stocks, four were superior in respect of cup characters. The experiment is being continued further.

Nitrogen vs. clone: Leaf samples of Tocklai released clones from areas using nitrogenous manure were manufactured by orthodox and C.T.C. methods to see the effect of nitrogen in cup characters. Further investigation in this line is being followed up.

Different methods of bringing up of young tea : Two estate clones and one stock were manufactured by orthodox and C.T.C. methods to see the effect on cup characteristics of different methods adopted for bringing up of young tea. There was no difference in the quality of young tea during the formative stages

when grown up by different methods. Quality difference was, however, noticeable with different prunings and skiffings and kind of jat and clones.

PRODUCT DIVERSIFICATION

Green tea

Manufacturing trials on green tea were conducted in different estates throughout the season. The investigations were based on :

1. Effect of withering on appearance and cup characters of made tea.

Treatment A -- No wither (Control)
Treatment B - Two hours withering
Treatment C - Four hours withering
Treatment D -- Six hours withering

Treatment A gave good result in all respect followed by Treatment B. Four (Treatment C) and Six (Treatment D) hours wither gave slightly tinged colour and were not green in appearance. Treatments B, C and D produced hard stalk and bold yellow leaf with increased percentage of sowmee (Dust) grade. The liquors in cup were deep in colour resembling black tea liquor and were not sweet in taste as in Treatment.

2. Effect of rolling pressure, rolling time and different types of rolling on appearance, grade percentage and quality.

Treatment E -- Light pressure
Treatment F -- Medium pressure
Treatment G -- Heavy pressure
Treatment H -- Cap just Floating i.e. no pressure (Control)

Treatment G (Heavy pressure) during rolling after steaming accelerated the twisting action and increased the percentage of Dhulli with reduction of the quantity of bold leaf as well as percentage of sowmee (Dust). Treatment G was followed by Treatment E (Medium pressure).

Application of heavy pressure (Treatment G) during rolling raised the temperature of the rolling drum which caused exposition of red stalk when the leaf was not properly boiled or steamed.

3. Effect of different plucking rounds on appearance, and cup characters of made tea.

Treatment 1 — 7 days plucking (Control)
Treatment 2 — 9 days plucking
Treatment 3 -- 11 days plucking
Treatment 4 — 13 days plucking

In this experiment Treatment 1 gave good cup quality followed by Treatment 2. Leaf from seven day round gave somewhat less bold yellow leaf and sowmee (Dust) than that from nine day round. Longer plucking rounds gave inferior results.

Advisory work

(a) 14 group tasting sessions were arranged by the Area Scientific Committees in different parts of N.E. India. The tasting sessions were followed by discussions on manufacture under different factory conditions. Visits were paid wherever necessary. The Tea Tasters visited 90 tea factories to advise on manufacturing problems.

(b) **Seminars :** Three seminars on Engineering and Manufacture and two seminars on Agriculture and Soils in different parts of N.E. India were attended by the Tea Tasters during the season.

(c) **Tasting :** Number of tea samples tasted during the year at :

Tocklai 15020
Nagrakata 18880

Highlights

The teething troubles with the commercial 45 cm Boruah Continuous Roller manufactured by M/s Steelsworth Ltd. have now been sorted out. New units manufactured by this from are functioning satisfactorily.

A Boruah Continuous Roller of 40 cm size has now been designed and its construction completed. This machine with the two earlier prototypes of 45 cm and 37 cm size in tandem will be used for a continuous two roll (1st and 2nd) orthodox rolling system.

A model has been made and tried for mechanical separation of stalks from made tea. A pilot model of a continuous withering machine has also been constructed.

In the collaborative projects taken up with C.M.E.R.I., mathematical computations of stress in an orthodox roller have been completed and a model for studying the possibility of changing its design has been constructed at C.M.E.R.I. Six pairs of C.T.C. segments made of different materials have been sent by C.M.E.R.I. for trials. A design of a fluidised bed coal heater suitable for tea has been prepared at C.M.E.R.I. Studies on withering systems and plucking machine are in progress.

CONTINUOUS GREEN LEAF PROCESSING MACHINES

(i) Boruah Continuous Roller

The first unit of 45 cm Boruah Continuous Roller (B.C.R.) manufactured by M/s Steelsworth Ltd., which was completely renovated and sufficiently strengthened, is running without any mechanical trouble now and continues to give satisfactory results. The second unit manufactured by the same firm is installed at Bazaloni T.E. and is working satisfactorily. Bazalani teas manufactured in this machine are given distinctly higher valuations by broker house tasters than the conventional Bazalani teas. Two more machines manufactured by this firm are now being installed at Kakajan T.E.

For development of the Boruah Continuous Roller for the first roll, for which two passes through the machine are found necessary, a 40 cm prototype has been constructed to work as the second pass machine, As the capacity during the second pass is higher than in the first pass the 40 cm prototype should be able to take the output from a 45 cm B.C.R. working as first pass machine. These two prototypes for the first roll along with the existing 37 cm prototype for the 2nd roll are shifted to Hunwal T.E. where they are being installed. Trial of all the three together in tandem for first and second roll will be started soon.

(ii) Development of Withered Leaf Preconditioner:

Some further trials were conducted with the withered Leaf Preconditioner at the pilot factory. Withered leaf preconditioned in this machine was rolled in a conventional roller and was compared with leaf rolled in the conventional manner. The comparative valuations given by Tocklai Tasters and a broker house taster are given in table 10.01.

Table 10.01 *Comparative valuations of preconditioned and conventional teas in Rs/kg.*

Date	1st fine: With preconditioner	1st fine: Without preconditioner	Coarse: With preconditioner	Coarse: Without Preconditioner
		Tocklai Taster (A)		
16.8.80	16.00	20.00	16.00	16.00
19.9.80	20.00	20.00	16.00	18.00
23.9.80	20.00	20.00	16.00	16.00
30.9.80	20.00	18.00	16.00	20.00
1.10.80	20.00	20.00	18.00	18.00
7.10.80	20.00	20.00	16.00	18.00
8.10.80	18.00	20.00	16.00	18.00
10.10.80	18.00	20.00	16.00	18.00
11.10.80	20.00	18.00	18.00	16.00
11.10.80	18.00	20.00	16.00	18.00
		Tocklai Taster (B)		
16.9.80	9.00	10.00	7.00	8.00
19.9.80	9.00	8.50	7.00	7.50
23.9.80	9.00	9.00	7.00	7.00
30.9.80	10.00	10.00	8.00	7.00
1.10.80	10.00	10.00	7.00	8.00
7.10.80	8.00	8.00	7.00	7.00
8.10.80	8.00	9.00	7.00	7.00
10.10.80	7.00	8.00	7.00	7.00
11.10.80	9.00	7.00	7.00	7.00
11.10.80	8.00	9.00	7.00	7.00
		Broker House Taster		
16.9.80	12.00	13.00	12.00	12.00
19.9.80	13.00	14.00	12.00	13.00
23.9.80	12.00	12.00	12.00	12.00
30.9.80	13.00	12.00	12.00	12.00
1.10.80	12.00	12.00	12.00	12.00
7.10.80	13.00	16.00	12.00	12.00
8.10.80	12.00	13.00	12.00	12.00
10.10.80	12.00	12.00	12.00	12.00
11.10.80	12.00	12.00	12.00	12.00
14.10.80	12.00	13.00	12.00	12.00

The table shows that the preconditioner is unable to add anything to the valuation of tea particulary in case of coarse mal.

Plucking Aid

A two stroke engine operated plucking aid received from Japan along with a battery operated Japanese plucking aid received earlier have been tried out at Tocklai's experimental plots. Due to various difficulties like inexperienced workers and frequent interruptions, the experiment could not be conducted properly. The trials will be done again next year.

In the meantime the manual plucking aid developed earlier at Tocklai has been fitted with a 12 volt d.c. motor having sufficient power for its operation. Total weight of this plucking aid including the motor is more than a similar Japanese device. Some trials are proposed to test the performance of our device.

...ing of Made

Some trials were condu... a model developed for separation of stalks from orthodox teas. The results so far obtained show that although some amount of stalks are separated from the coarse mal, the grades are not free from stalks. Further work with different models is continued.

Development of Withering Equipment

Construction of a model of a new continuous and compact withering system has now been completed. Minor defects and inaccuracies found on tests conducted for its mechanical performance have been rectified. Trials with tea leaves will be started soon.

Collaboration with CMERI

Orthodox Roller : Mathematical computations of stress distribution analysis in an orthodox roller has been done and a model for studying the possibility of changing its design has been constructed at CMERI.

C.T.C. Segment Material : CMERI Scientists have sent two pairs of cast iron and cast steel segments which have been machined at Tocklai and returned to CMERI for surface treatment. These pairs have now been received back for trial. Another four pairs of segments made of manganese-bronze, phosphor-bronze, aluminium-bronze and aluminium alloy have also been received. These are being machined at Tocklai for trials in the next season. Two pairs of miniature C.T.C. rollers have already been made for the purpose. A mini C.T.C. machine is also being constructed.

Fluidised bed burner : Computations have been completed and a design has been prepared for a fluidised bed coal heater with an expected efficiency of 67 per cent. Low grade and high sulphur coals can be used in this heater.

Pulse engine sprayer : A prototype pulse engine sprayer is now ready at CMERI. Although a temperature of 800°C is developed in the machine, the temperature at the spray nozzle is only 50°C and at a distance of 5 ft. from the nozzle the temperature is below ambient. The sprayer has a long throw and the particle size appears to be small enough for a low volume sprayer with good foliage penetration capacity. The weight of the sprayer with a mild steel tank is 22 kg and there is enough scope to reduce its weight to an acceptable limit.

Withering system and plucking Machine: Studies are being made in the two subjects at CMERI. Some tours to tea areas have been undertaken for the purpose and a visit to Tocklai is proposed to see the Japanese plucking aids.

Meetings and Seminars

Three seminars on Engineering and Manufacturing held by different Area Scientific Committees and two meetings of Engineering Sub-committee were attended by the Head, Engineering R & D Department. He served in the committee for doing the costing of the 45 cm Boruah Continuous Roller.

Highlights

Summarisation of past experiments on irrigation of mature tea indicates the scope for increasing the yield by irrigation in certain regions of North East India provided the appropriate period and quantity of irrigation could be ascertained.

Results obtained so far from present experiments on irrigation of mature tea, which are in progress one each at Dam Dim T.E. (Dooars) and Tocklai Division (Jorhat), in general, support the statistical findings based on crop-weather studies.

Results from NPK response surface experiments on mature tea combined over years 1977 to 1979, which is the second pruning cycle of the experiments, showed maximum observed yield with higher than 135 kg of Nitrogen/ha with different combinations of Phosphate and Potash in all the regions except in Cachar, where it was 100 kg Nitrogen/ha. In general response due to Phosphate and Potash was obtained in all the regions. However, optimum combination of N, P and K which would give maximum yield, could not yet be ascertained.

Maximum quantity of total rainfall which is expected in each month, on an average once in every 2, 5 and 10 years was found out for Nagrakata (Dooars), Nagrifarm (Darjeeling) and Silcoorie (Cachar).

CROP-WEATHER AND IRRIGATION

Summarisation of 13 past experiments on irrigation was carried out during the period to find out the trend of results in order to design new irrigation experiments in different soil-climatic and drought prone regions of North East India. These experiments on irrigation of mature tea were initiated and completed sometime during 1963 to 1972. These 13 experiments were divided into two categories, viz., experiments having only one irrigation treatment as the first category and having more than one irrigation treatment as the second category. Seven out of these thirteen experiments were laid out with only one irrigation treatment and were tested against no irrigation. Other treatments in these experiments were pruning time (viz., December pruning and July pruning), severity of cut etc. The irrigation treatments were not very well defined. Much stress was put on to garden practice of irrigation. The summarised results of these experiments are presented in Table 11.01.

From the table (Table 11.01) it can be seen that response due to irrigation failed to show pronounced effect either on the whole season's crop or in the distribution of early, main and back-end crop except in Dejoo Valley T.E. in Nowgong Circle, where early crop increased by about 20 per cent and the whole season's crop by about 10 per cent. The reason might be that the effective irrigation treatment could not be chosen in those experiments; because there were only one type of irrigation treatment and also the irrigation treatment varied from year to year subjectively including pump failure in some cases. Further, the reason for depression in crop due to irrigation in three experiments, perhaps might be for excess water. Therefore, no definite conclusion could be drawn from these experiments.

Table 11.02 shows the summarised results obtained from the remaining six irrigation experiments where 3 or 5 irrigation treatments were tried.

Table 11.01. *Percentage increase (+) or decrease (−) in yield due to irrigation over no irrigation*
(Experiments with only one irrigation treatment)

Region	Expt. No.	Site of the Expt. and Circle	Period of experimentation	Average percentage increase (+) or decrease (−) in yield over the period of experimentation against no irrigation: Early	Main	Back-end	Whole	Description of the Irrigation treatment	Remarks
	AS 67	Borahi T. E. (Sonari)	1967–'71	+ 1.02 (10)	− 3.20 (33)	8.11 (24)	2.03 (47)	As per garden practices	Irrigation treatment varied from year to year
Sibsagar	AS 68	Gorunga T. E. (Golaghat)	1967–'71	+ 5.90 (33)	+ 11.36 (107)	+ 3.45 (12)	+ 8.27 (152)	-do-	-do-
	AS 70	Gabroo Purbat T.E. (Jorhat)	1967–'69	4.87 (42)	12.69 (131)	− 14.04 (41)	9.83 (214)	-do-	-do-
Nowgong	AS 73	Dejoo Valley T.E. (Nowgong)	1967–'70	+ 20.50 (122)	+ 6.00 (55)	+ 1.12 (4)	+ 9.69 (181)	-do-	-do-
	AN 74	Durrung T. E. (Tezpur)	1967–'70	− 10.95 (83)	− 2.39 (20)	− 5.53 (12)	6.35 (115)	5cm (2") Irrigation per month during December to April	-do-
Darrang	AN 75	Mazbat T.E. (Borsola)	1967–'70	+ 6.07 (44)	− 1.67 (16)	3.27 (10)	+ 0.90 (18)	-do-	-do-
Dooars	D 35	Gopalpur T. E. (Dalgaon)	1968–'72	+ 13.71 (160)	+ 1.12 (7)	− 3.47 (14)	+ 6.96 (153)	5 cm (2") Irrigation per month during January to April	—

Note : Figures within bracket indicate actual increase or decrease in yield (made tea in kg/ha) due to irrigation over no irrigation.

The percentage increase/decrease in crop was calculated on the basis of the irrigation treatment which gave the highest yield over the period of experimentation, and compared against no irrigation. The description of the irrigation treatment giving highest yield is shown in the table (Table 11.02).

Table 11.02. *Percentage increase (+) or decrease (—) in yield due to best irrigation treatment over no irrigation*
(Experiments with more than one irrigation treatments)

Region	Expt. No.	Site of the Expt. and Circle	Period of experimentation	Average percentage increase (+) or decrease (–) in yield over the period of experimentation against no irrigation				Description of the irrigation treatment giving highest yield	Remarks
				Early	Main	Back-end	Whole		
	AS 52	Amluckie T.E. (Nowgong)	1963-'65	+32.60 (104)	+4.31 (89)	-	+8.09 (192)	T_1: Irrigation till soil moisture is 90% at 60 cm depth Irrigation applied during December to March.	Main and Back-end seasons' crops are merged.
Nowgong	AS 52	do	1968-'69	+30.93 (202)	+20.68 (232)	+0.44 (2)	19.41 (433)	T_2: 5 cm irrigation per month at 1.75 cm for three times at 10 days intervals from mid-December to mid-March.	Treatments were modified in 1967.
	AS 72	Dejoo Valley T. E. (Nowgong)	1967-'68	+25.89 (88)	+10.77 (138)	-	+13.94 (226)	(A) T_5: 5 cm irrigation per month from December to March in one application.	Main and Back-end seasons' crops are merged.
	AN 55	Balipara T.E. (Tezpur)	1963-'67	+25.91 (85)	+5.01 (87)	—	+8.28 (172)	T_2: Irrigation is stopped when a fixed quantity of water is applied in 10 hours of irrigation (Estate practice).	do
Tezpur	AN 61	Sessa T. E. Tezpur	1966-'72	+28.70 (99)	+6.86 (83)	+5.25 (20)	+10.13 (202)	T_2: 5 cm irrigation per month during December to March.	
Dooars	D 36	Ranicherra T. E. (Dam Dim)	1969-'72	+33.04 (260)	+13.38 (174)	+15.48 (113)	+19.42 (547)	T_3: Rain +10 cm irrigation for every four weeks from January to April	
Terai	TR 1	Terrihannah T.E. (Terai)	1969-'72	+18.98 (175)	+10.04 (114)	0 (0)	+10.74 (289)	T_5: Rain + 5 cm of irrigation at every two weeks starting from January to April.	Crop-distribution for 1971 is not available and therefore, not included.

Note : Figures within bracket indicate actual increase or decrease in yield (made tea kg/ha) due to irrigation over no irrigation.

(A) : 1. Any rainfall during the irrigation period was deducted from the amounts scheduled to be supplied, provided the rainfall was in excess of 1.25 cm within 48 hours during any cloudy spell.

2. Irrigation on the basis of moisture meter reading which gave highest yield was not considered for percentage calculation, as the treatment was modified in 1968 due to unreliability of the moisture meter. Therefore, treatment T_5 which gave the next highest yield was considered for percentage calculation.

It can be seen that the irrigation treatment presented in the table (Table 11.02) gave 26% to 33% increase in early crop in Nowgong and North Bank circles of Assam where the whole season's crop also recorded considerable increase ranging from 8% to 19%. The early crop increased by about 33 % in Dam Dim circle in Dooars and 19% in Terai where the whole season's crop also increased by 19% and 11% respectively.

In one experiment in North Bank considerable decrease in crop was indicated when irrigation was stopped after continued irrigation for 6 years. However, there is need for further experimentation to arrive at some definite conclusion on this aspect.

These results indicate that there are, possibly, ample scope to increase the crop yield in certain regions as well as effect distribution of crop gainfully provided the appropriate period and quantity of irrigation could be ascertained. This suggests the need for further investigation on this aspect.

A study to find out the most critical periods and quantity of rain in each period which affect the annual yield of tea, their nature of relationship with the yield, and to predict the irrigation requirements, if any, during the dry periods, the need to drain out excess rain water, if any, during the monsoon periods, and also to estimate the gain in yield due to such measures for the Borsola sub-district, North Bank continued during the year.

Similar study was completed for ten sub-districts, which covered eight sub-districts in Dooars and Terai, one in South Bank and one in North Bank.

These results need to be tested by laying out field experiments. As such, one experiment in Dooars (Dam Dim T.E.) was initiated in 1977 and one in Jorhat (Tock-

lai Division) from 1979, where some of the treatments were based on the above statistical findings and other treatments in one experiment were based on the evaporation and soil moisture status to test the irrigation requirements.

The results so far obtained from these two experiments, are encouraging. In general, the results support the statistical findings based on the crop-weather study for these two circles. The results of these two experiments are reported by Advisory and Agronomy Departments.

ANALYSIS TECHNIQUES FOR LONG-TERM EXPERIMENTAL DATA

The object of this study and some results were reported in the Annual Scientific Reports, 1978-'79, pp. 74-76 and 1979-'80, p.81. The study continued during the year to find out the appropriate error structure by different statistical techniques.

COLLABORATIVE PROJECTS

(a) NPK response surface

In order to find out the optimum requirements of N, P and K to obtain maximum yield, the experiments were laid out in a Second Order Central Composite Rotatable design. In this design out of 125 possible combinations, 15 distinctly different N, P and K combinations are required to be tested in the field to obtain the response surface.

Analysis of NPK response surface data for the years 1977, 1978 and 1979, covering the second pruning cycle of the 26 experiments on mature tea spread over 13 sites of North East India was carried out during the year. These experiments were initiated in 1973. Combination of experiments over sites within a region and over years 1977-'79 were decided on the basis of appropriate testing of the response surfaces. The results showed that there was no significant difference in responses amongst sites within North Bank, Cachar and Darjeeling. But, within South Bank, Dooars and Terai, significant difference in responses between sites was observed. Accordingly, experiments were combined within a region. Thus, there were eight response surfaces after combination of the surfaces.

Considering the 15 applied treatments in all the regions, maximum yield was observed with 160 to 200 kg of Nitrogen/ha with different combinations of Phosphate and Potash though optimum Nitrogen level had not yet been marked out. In Cachar, however, 100 kg N/ha gave maximum yield. The quantity of Phosphate and Potash with Nitrogen which gave maximum yield, varied from 50 to 100 and 75 to 120 kg/ha respectively in Panitola sub-area of Upper Assam, Darjeeling, Western Dooars & Terai, North Bank and Cachar. Whereas, in Eastern Dooars and in Doom Dooma sub-area of Upper Assam, 20 kg Phosphate/ha and 120 kg Potash/ha with [illegible] Nitroge[illegible] proved to be the best combination for observed maximum yield. Further, the requirement of Phosphate and Potash in mid and lower Assam was found to be low.

It may be mentioned here that at the end of [illegible] years of experimentation, the optimum combination of Nitrogen, Phosphate and Potash for maximum yield in different regions could not yet be ascertained. The experiments are being continued.

(b) Studies on rainfall probabilities

A study was carried out with 11 years rainfall data (1968-'78) recorded at Nagrakata (Dooars), Nagrifarm (Darjeeling) and Silcoorie (Cachar) to find out the maximum quantum of total rainfall to be expected in a month once every 2, 5 and 10 years at each of these places. This may, however, not occur at constant intervals of 2, 5 and 10 years.

This study is of great importance in deciding the magnitude of success of various field management practices in tea, particularly of irrigation and drainage problems.

The probabilities of occuring an event with 95%, 90% and 80% chances for different return periods, i.e., 2. 5 and 10 years are presented in tables 11.03, 11.04 and 11.05 for Nagrakata (Dooars), Nagrifarm (Darjeeling) and Silcoorie (Cachar) respectively.

Lower and Upper limits for each confidence (probability) levels were obtained to ascertain the accuracy of the predicted maximum values within which the actual value would lie. For example, from Figure 11.01

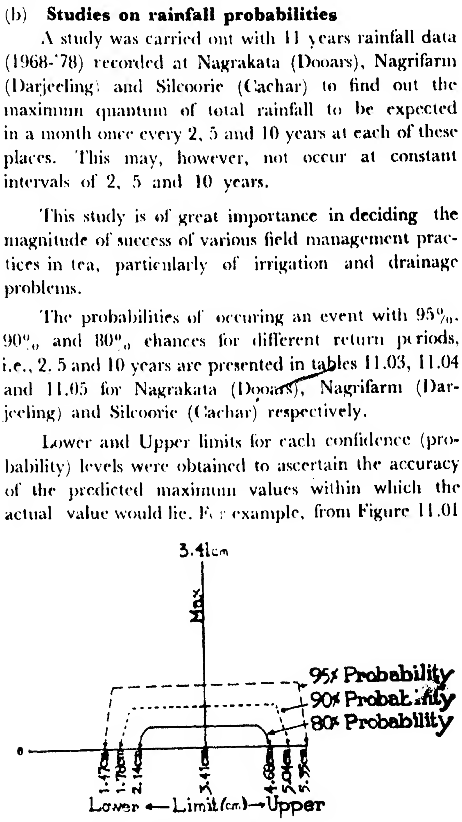


Fig 11.01 January rainfall return period.

it can be seen that in January for Nagrakata, for the return period of 10 years with 80% probability, the lower and upper limits of maximum rainfall are 2.14 cm and 4.68 cm respectively. This means that there is a 80% probability that the actual maximum rainfall in January once in 10 years will lie between 2.14 and 4.68 cm.

STATISTICAL SERVICE FUNCTION

Statistical planning, designing, arrangements of blocking on the basis of pre-treatment yields to minimise the variation between plots within a block, and

Table 11.83. *Monthly maximum rainfall (cm) for different return periods with lower and upper limits : 1968-'78*
Region: Nagrakata (Dooars)

Return period (Year)	Probability (%)	January: Maximum Rain-fall (cm)	January: Lower limit (cm)	January: Upper limit (cm)	February: Maximum rain-fall (cm)	February: Lower limit (cm)	February: Upper limit (cm)	March: Maximum rain-fall (cm)	March: Lower limit (cm)	March: Upper limit (cm)	April: Maximum rain-fall (cm)	April: Lower limit (cm)	April: Upper limit- (cm)	May: Maximm rain-fall (cm)	May: Lower limit (cm)	May: Upper limit (cm)	June: Maximum rain-fall (cm)	June: Lower limit (cm)	June: Upper limit (cm)
	95		0.23	1.63		0.28	3.64		0.74	3.64		9.95	21.23		33.49	51.13		74.66	96.78
2	90	0.93	0.34	1.52	1.96	0.55	3.37	2.19	0.97	3.41	15.59	10.86	20.32	42.31	34.90	49.72	85.72	76.44	95.00
	80		0.47	1.39		0.86	3.06		1.24	3.14		11.90	19.28		36.54	48.08		78.49	92.95
	95		1.04	3.80		2.23	8.87		2.42	8.14		16.50	38.72		43.75	78.51		87.51	131.09
5	90	2.42	1.26	3.58	5.55	2.77	8.33	5.28	2.88	7.68	27.61	18.28	36.94	61.13	46.54	75.72	109.30	91.01	127.59
	80		1.52	3.32		3.38	7.72		3.41	7.15		20.34	34.88		49.76	72.50		95.05	123.55
	95		1.47	5.35		3.25	12.61		3.29	11.35		19.92	51.24		49.08	98.08		94.20	155.62
10	90	3.41	1.78	5.04	7.93	4.01	11.85	7.32	3.94	10.70	35.58	22.44	48.72	73.58	53.02	94.14	124.91	99.14	150.68
	80		2.14	1.68		4.87	10.99		4.69	9.95		25.34	45.82		57.55	89.61		104.82	145.00

July: Maximum rain fall (cm)	July: Lower limit (cm)	July: Upper limit (cm)	August: Maximum rain-fall (cm)	August: Lower limit (cm)	August: Upper limit (cm)	September: Maximum rain-fall (cm)	September: Lower limit (cm)	September: Upper limit (cm)	October: Maximum rain-fall (cm)	October: Lower limit (cm)	October: Upper limit (cm)	November: Maximum rain-fall (cm)	November: Lower limit (cm)	November: Upper limit (cm)	December: Maximum rain-fall (cm)	December: Lower limit (cm)	December: Upper limit (cm)
	79.01	115.31		57.59	82.65		46.82	63.34		15.26	32.16		0	5.91		0	0.71
97.16	81.92	112.40	70.12	59.61	80.63	55.08	48.15	62.01	23.71	16.62	30.80	2.82	0.23	5.41	0.28	0	0.64
	85.29	109.03		61.93	78.31		49.68	60.48		18.18	29.24		0.80	4.84		0	0.56
	100.13	171.65		72.14	121.50		56.42	88.98		25.08	58.38		3.32	15.50		0.34	2.04
135.89	105.88	165.90	96.82	76.11	117.53	72.70	59.04	86.36	41.73	27.76	55.70	9.41	4.30	14.52	1.19	0.48	1.90
	112.50	159.28		80.68	112.96		62.05	83.35		30.84	52.62		5.43	13.39		0.64	1.74
	111.09	211.91		79.73	149.29		61.42	107.30		30.19	77.13		5.19	22.35		0.61	2.99
161.50	119.20	203.80	114.51	85.32	143.70	84.36	65.11	103.61	53.66	33.97	73.35	13.77	6.57	20.97	1.80	0.80	2.80
	128.53	194.47		91.76	137.26		69.36	99.36		38.31	69.01		8.16	19.38		1.02	2.58

Table 11.04. *Monthly maximum rainfall (cm) for different return periods with lower and upper limits : 1968—'78*
Region : Nagrifarm (Darjeeling)

Return period (Year)	Probability (%)	January: Maximum rain-fall (cm)	January: Lower limit (cm)	January: Upper limit (cm)	February: Maximum rain-fall (cm)	February: Lower limit (cm)	February: Upper limit (cm)	March: Maximum rain-fall (cm)	March: Lower limit (cm)	March: Upper limit (cm)	April: Maximum rain-fall (cm)	April: Lower limit (cm)	April: Upper limit (cm)	May: Maximum rain-fall (cm)	May: Lower limit (cm)	May: Upper limit (cm)	June: Maximum rain-fall (cm)	June: Lower limit (cm)	June: Upper limit (cm)
	95		0.88	2.12		0.50	2.96		1.60	4.92		6.11	15.37		16.45	22.81		34.82	51.42
2	90	1.50	0.98	2.02	1.73	0.70	2.76	3.26	1.87	4.65	10.74	6.86	14.62	19.63	16.96	22.30	43.12	36.16	50.08
	80		1.10	1.90		0.93	2.53		2.18	4.34		7.71	13.77		17.55	21.71		37.69	48.55
	95		1.60	4.04		1.93	6.77		3.53	10.05		11.49	29.73		20.14	32.66		44.46	77.16
5	90	2.82	1.80	3.84	4.35	2.32	6.38	6.79	4.05	9.53	20.61	12.96	28.26	26.40	21.15	31.65	60.81	47.09	74.53
	80		2.02	3.62		2.77	5.93		4.65	8.93		14.65	26.57		22.31	30.49		50.12	71.50
	95		1.97	5.41		2.67	9.49		4.53	13.73		14.30	40.00		22.06	39.70		49.49	95.57
10	90	3.69	2.25	5.13	6.08	3.22	8.94	9.13	5.27	12.99	27.15	16.36	37.94	30.88	23.48	38.28	72.53	53.19	91.87
	80		2.57	4.81		3.85	8.31		6.12	12.14		18.74	35.56		25.11	36.65		57.46	87.60

July: Maximum rain-fall (cm)	July: Lower limit (cm)	July: Upper limit (cm)	August: Maximum rain-fall (cm)	August: Lower limit (cm)	August: Upper limit (cm)	September: Maximum rain-fall (cm)	September: Lower limit (cm)	September: Upper limit (cm)	October: Maximum rain-fall (cm)	October: Lower limit (cm)	October: Upper limit (cm)	November: Maximum rain-fall (cm)	November: Lower limit (cm)	November: Upper limit (cm)	December: Maximum rain-fall (cm)	December: Lower limit (cm)	December: Upper limit (cm)
	46.24	67.28		34.17	49.61		24.15	37.93		2.38	26.82		0.24	1.48		0	0.53
56.76	47.93	65.59	41.89	35.41	48.37	31.04	25.26	36.82	14.60	4.34	24.86	0.86	0.34	1.38	0.15	0	0.47
	49.88	63.64		36.84	46.94		26.53	35.55		6.61	22.59		0.46	1.26		0	0.40
	58.46	99.92		43.15	73.57		32.16	59.30		16.58	64.72		0.96	3.38		0.20	1.72
79.19	61.80	96.58	58.36	45-59	71.13	45.73	34.34	57.12	40.65	20.45	60.85	2.17	1.15	3.19	0.96	0.33	1.59
	65.63	92.75		48.41	68.31		36.85	54.61		24.91	56.39		1.38	2.96		0.47	1.45
	64.84	123.26		47.82	90.70		36.33	74.57		23.97	91.83		1.33	4.75		0.45	2.57
94.05	69.53	118.57	69.26	51.26	87.26	55.45	39.40	71.50	57.90	29.42	86.38	3.04	1.60	4.48	1.51	0.62	2.40
	74.94	113.16		55.23	83.29		42.94	67.96		35.71	80.09		1.92	4.16		0.81	2.21

.05. *Monthly maximum rainfall (cm) for different return periods with lower and upper limits : 1968-'78*
Region : Silcoorie (Chachar)

Return period (Year)	Probability (%)	January Maximum rainfall (cm)	January Lower limit (cm)	January Upper limit (cm)	February Maximum rainfall (cm)	February Lower limit (cm)	February Upper limit (cm)	March Maximum rainfall (cm)	March Lower limit (cm)	March Upper limit (cm)	April Maximum rainfall (cm)	April Lower limit (cm)	April Upper limit (cm)	May Maximum rainfall (cm)	May Lower limit (cm)	May Upper limit (cm)	June Maximum rainfall (cm)	June Lower limit (cm)	June Upper limit (cm)
	95		0.26	1.68		1.84	6.06		5.14	14.56		23.25	43.23		25.97	47.61		47.74	68.42
2	90	0.97	0.37	1.57	3.95	2.18	5.72	9.85	5.89	13.81	33.24	24.86	41.62	36.79	27.71	45.87	58.08	49.41	66.75
	80		0.50	1.41		2.57	5.33		6.77	12.93		26.71	39.77		29.71	43.87		51.32	64.84
	95		1.09	3.89		4.29	12.61		10.62	29.20		34.86	74.22		38.55	81.19		59.76	100.48
5	90	2.49	1.31	3.67	8.45	4.96	11.94	19.91	12.12	27.70	54.54	38.02	71.06	59.87	41.97	77.77	80.12	63.03	97.21
	80		1.57	3.41		5.73	11.17		13.81	25.98		41.67	67.41		45.92	73.82		66.80	93.44
	95		1.52	5.48		5.56	17.28		13.47	39.65		40.90	96.38		45.10	105.20		66.01	123.41
10	90	3.50	1.84	5.16	11.42	6.50	16.34	26.56	15.57	37.55	68.64	45.36	91.92	75.15	49.93	100.37	94.71	70.62	118.80
	80		2.21	4.79		7.59	15.25		18.00	35.12		50.50	86.78		55.49	94.81		75.94	113.48

July Maximum Rain-fal(c n	July Lower limit (cm)	July Upper limit (cm)	August Maximum rain-fall (cm)	August Lower limit (cm)	August Upper limit (cm)	September Maximum rain-fall (cm)	September Lower limit (cm)	September Upper limit (cm)	October Maximum rain-fall (cm)	October Lower limit (cm)	October Upper limit (cm)	November Maximum rain-fall (cm)	November Lower limit (cm)	November Upper limit (cm)	December Maximum rain-fall (cm)	December Lower limit (cm)	December Upper limit (cm)
	46.46	56.72		38.25	49.63		19.81	37.87		11.24	20.72		2.87	8.09		0	2.11
51.59	47.29	55.89	43.94	39.17	48.71	28.84	21.26	36.42	15.98	12.00	19.96	5.48	3.29	7.67	0.70	0	1.88
	48.24	54.94		40.22	47.66		22.94	34.74		12.88	19.08		3.78	7.18		0	1.62
	52.42	72.52		44.87	67.27		30.31	65.87		16.75	35.43		5.90	16.18		0.93	6.47
62.52	54.04	71.00	56.07	46.67	65.47	48.09	33.16	63.02	26.09	18.26	33.92	1.04	6.73	15.35	3.70	1.37	6.03
	55.92	69·12		48.74	63.40		36.46	59.72		19.98	32.20		7.68	14.49		1.89	5.51
	55.52	83.98		48.31	79.89		35.78	85.90		19.62	45.94		7.47	21.95		1.78	9.60
59.75	57.80	81.70	64.10	50.85	77.35	60.84	39.80	81.88	32.78	21.74	43.82	14.71	8.64	20.78	5.69	2.41	8.97
	60.44	79.06		53.77	74.43		41.45	77.23		24.17	41.39		9.98	19.44		3.13	8.25

randomisation for different research projects, were carried out for a number of experiments. In addition to this, method of analysis was also determined for a number of projects/experiments.

DATA PROCESSING UNIT

Field and laboratory experimental records for 1979 and 1980 on computerised proforma poured in practically from all the research departments and from the member estates of North East India. Weekly/monthly/yearly yield and other experimental records for large number of experiments were received during the period. These records were checked, punched and verified on the Unit Record Machines at Tocklai. Computations of these were carried out on the Unit Record Machines at Tocklai and on the Electronic Computers at the I.S.I., Calcutta and I.I.T., Madras. In this connection, computer programmes were written in FORTRAN-IV language for computations of the complex problems on the Electronic Computer. In addition to these, accounts jobs and preparation of quarterly membership subscription bills for the T.R.A. member estates of North East India were carried out on the Unit Record Machines.

It may be mentioned here that much of the backlog are there because of the abnormal situation that existed during the year under review when many working days were lost.

Agricultural Economics

Highlights

Based on figures received from 454 member tea estates, the tea yield for the whole of N.E. India showed an increasing trend of 2.85% per annum for the decade 1970-79.

Cost of replantation during 1979-80 ranged from 3260 to 3681 killograms made tea per hectare (KMTH) in the plains of N.E. India. The yield trend for tea bushes planted during 1973-78 was much higher than those planted during 1969-72 and 1961-68, thus reducing the pay back period considerably. Increase of the rate of interest from 11% to 18%, prolonged the pay back period by 0.8 to 11.1 years. The progress of replantation has been slow. A comparison of extension planting with replantation showed the former to be more advantageous.

Based on a pilot study of five estates in Assam Valley, the cost of manufacture was observed to vary between Rs. 1.26 and Rs. 2.01 per kg of made tea.

Two Tea Economics Courses were conducted during August, 1980.

Decade performance of TRA member estates: The department started the study on the trend of productivity of TRA member estates since 1975-76. With the completion of the decade 70's the performance of TRA member estates has been computed for the period. In view of the size and importance of N.E. Indian tea industry as landholder, employer and exporter, the productivity survey is essential since it gives an idea of the way growth has taken place and indicates steps to achieve higher target fixed for the future.

The decade performance is based on the data Supplied by 454 TRA member estates for the period 1970-79. The performance was computed by Least Square straight line method. The responding estates were informed about their performance in relation to the respective sub-area.

During the decade (70's) the yield per hectare for the whole of N.E. India increased @ 2.85% per annum. The region-wise increase is given below :

Region		Percent annual increase
Upper Assam (S. Bank)		2.83
Central & Lower Assam (S.Bank)		2.50
North Bank		3.22
Cachar & Tripura		3.80
Dooars		3.00
Terai		3.40
Darjeeling	Average	2.85

These district-wise yield trends were further studied for each sub-area, on the basis of responding estates. The results are given below.

Table 12.01 *Per cent annual yield increase during seventies in different Sub-districts.*

Sub-district	No. of TRA estates sampled	Per cent annual yield increase
Darjeeling Central	5	1.63
Darjeeling East	7	1.10
Darjeeling West	7	1.88
Teesta Valley	4	1.65
Sonada	6	2.42
Runghong Valley	7	0.53
Tingling	4	1.62
Kurseong	4	0.12
Mahanadi	4	1.83
Total Darjeeling	48	1.40
Terai	21	3.40
Jainti	8	2.86
Kalchini	9	3.42
Dalgaon	13	3.01
Binnaguri	9	3.45
Nagrakata	8	1.55
Chulsa	11	0.85
Dam Dim	18	3.00
Total Dooars	76	3.00
North Lakhimpur	6	2.34
East Boroi	9	3.50
Bishnauth	9	3.14
Tezpur	19	3.31
Borsola	4	2.37
Orang	6	3.16
Mangoldai	17	3.27
Goalpara	7	4.18
Total North Bank	77	3.22
Doom Dooma A	10	1.67
Doom Dooma B	5	3.84
Doom Dooma C	9	2.79
Doom Dooma D	9	2.79
Dibrugarh A	8	2.32
Dibrugarh B	9	1.80
Dibrugarh C	7	2.80
Panitola A	10	2.30
Panitola B	7	2.36
Naharkatia A	8	1.76
Naharkatia B	8	1.67
Moran A	10	1.93
Moran B	6	3.23
Tingrai A	10	5.47
Tingrai B	10	3.14
Total Upper Assam	126	2.83
Sonari & Nazira A	6	3.84
Sonari & Nazira B	8	3.13
Sonari & Nazira C	4	1.40
Jorhat A	6	0.36
Jorhat B	10	3.36
Jorhat C	6	2.04
Golaghat A	13	2.56
Golaghat B	8	2.05
Golaghat C	4	3.41
Nowgong	10	—0.40
Total Central & Lower Assam	75	2.50
Hailakandy	5	3.65
Karimganj & Longai	6	3.66
Happy Valley A	3	3.07
Happy Valley B	4	4.80
Chuttabheel	6	3.41
North Cachar	5	4.47
Tripura	2	2.99
Total Cachar & Tripura	31	3.80

The above table shows that except Nowgong sub-area of South Bank, Assam Valley, yield in every sub-area increased during the seventies, although the rate of increase differed between sub-areas.

Growth rate of Individual estates : The estates located in a sub-district are expected to achieve the growth rate of the sub-district as a whole but within each sub-district the estates have achieved different levels of growth during the last decade. The frequency distribution of the member estates with different rates of yield growth is shown in Table 12.02.

Table 12.02. *No. of sampled estates in each sub-district showing different yield growth rates.*

Sub-district	Negative	0 to 1	1 to 2	2 to 3	3 to 4	4 to 5	Above 5
	Per cent annual growth rate						
Darj. Central	1	1	1	—	1	1	—
Darj. East	1	2	2	1	1	—	—
Darj. West	1	2	—	3	—	—	1
Teesta Valley	1	—	1	1	—	1	—
Sonada	1	—	1	3	—	1	—
Rungbong Valley	2	1	3	1	—	—	—
Tingling	1	1	1	—	1	—	—
Kurseong	1	2	—	1	—	—	—
Mahanadi	1	—	1	2	—	—	—
Total Darjeeling	10	9	10	12	3	3	1
Terai	2	1	1	7	2	3	3
Jainti	—	—	2	3	2	—	1
Kalchini	1	—	—	4	—	1	3
Dalgaon	1	1	3	3	2	1	2
Binaguri	—	—	1	3	2	2	1
Nagrakata	—	1	3	1	1	—	2
Chulsa	1	1	2	1	4	2	—
Dam Dim	1	2	1	7	3	1	3
Total Dooars	4	5	12	22	14	7	12
North Lakhimpur	—	1	2	2	—	1	—
East Boroi	1	—	1	2	1	2	2
Bishnauth	—	—	—	4	2	1	2
Tezpur	—	—	5	3	5	3	3
Borsola	1	—	—	1	—	1	—
Orang	—	1	—	3	1	1	1
Mangaldai	1	2	2	4	3	4	3
Goalpara	—	1	1	—	—	—	5
Total N.Bank	3	5	11	19	12	13	16
Doom Dooma A	—	—	3	2	2	2	1
Doom Dooma B	—	1	—	1	1	1	1
Doom Dooma C	—	1	1	3	3	1	—
Doom Dooma D	—	—	—	3	4	1	1
Dibrugarh A	1	1	2	1	2	1	—
Dibrugarh B	—	2	3	2	2	—	—
Dibrugarh C	—	2	1	1	—	2	1
Panitola A	1	—	2	5	2	—	—
Panitola B	—	—	3	1	2	1	—
Naharkatiya A	2	1	2	—	1	2	—
Naharkatiya B	1	3	—	—	3	1	—
Moran A	1	3	2	4	—	—	—
Moran B	1	—	—	2	—	3	—
Tingrai A	—	1	—	1	1	5	2
Tingrai B	1	2	2	3	1	1	—
Total Upper Assam	8	17	21	29	24	21	6
Sonari & Nazira A	—	1	1	1	1	1	2
Sonari & Nazira B	—	1	—	4	2	1	—
Sonari & Nazira C	1	1	1	—	—	1	—
Jorhat A	3	2	1	—	—	—	—
Jorhat B	—	1	1	2	3	3	—
Jorhat C	2	1	1	1	—	—	1
Golaghat A	2	5	1	1	1	1	2
Golaghat B	1	—	4	1	—	2	—
Golaghat C	—	1	—	—	1	1	1
Nowgong	3	2	2	2	—	—	—
Total Central & Lower Assam	12	15	12	12	8	10	6
Hailakandy	—	1	1	1	1	—	1
Karimganj & Longai	—	1	2	1	2	—	—
Happy Valley A	—	—	—	1	2	—	—
Happy Valley B	—	1	—	—	—	—	3
Chuttabheel	1	—	2	1	—	—	2
North Cachar	1	—	—	1	—	2	1
Tripura	—	1	—	—	—	—	1
Total Cachar & Tripura	2	4	5	5	5	2	8
Total of N.E. India	41	55	71	106	68	59	54

The Advisory officers are now studying the yield trends of individual estates in their respective areas, to analyse the factors responsible for high and low yields and to suggest corrective measures, where necessary.

Economics of Replantation : The pay back period of replantation is calculated to find out the time it takes to recover the amount invested together with its interest and the loss of crop caused by uprooting. The following four factors are considered for calculating the pay back period of replantation.

(a) Yield at the time of uprooting
(b) Replantation expenses
(c) Rate of interest on investment
and (d) Yield pattern of replanted sections.

(a) **Yield at the time of uprooting :** In normal circumstances, uprooting should be at the point of Break Even Yield (BEY). When the yield is lower than BEY, the section does not contribute to the economy of the estate and hence uprooting would be desirable. As soon as it reaches BEY after replantation, it starts contributing. The yield levels of sections at the time of uprooting between 1961-68 and 1969-76 in different tea districts are given below in Table 12.03.

Table 12.03. *Yield kg per hectare at the time of uprooting of old sections*

Region	Uprooted during 1961-68	1969-76
1. Upper Assam (S.B.)	950	1132
2. Middle & Lower Assam (S.B.)	814	883
3. North Bank	957	1082
4. Dooars	942	1125
5. Terai	—	631

The data show that yields of sections uprooted during the 1969-76 period were much higher than those uprooted earlier in 1961-68. This will lead to lengthening of the pay back period in the latter case.

(b) **Replantation Expenses :** Replantation expenses include all the expenses incurred during five years from two years of uprooting, rehabilitation and planting to the first three years of maintenance. First year expenses include the total expenditure on uprooting tea bushes and shade trees, plus ancilliary operations including the raising of rehabilitation crop. The second year operations include the preparation of land, raising, carrying and planting of tea plants and shade trees (both temporary and permanent), mulching, drain making, manuring, weed pest and disease control and fencing the section (where necessary). Expenses during the next three years consist of pruning, pegging, infilling, mulching, manuring, weed, pest and disease control etc.

The Table 12.04 shows the expenses incurred during 1 year for uprooting and preparation of land including rehabilitation measures, in 0 year, for planting and in + 1, + 2 and + 3 years for maintenance. The cost is expressed in terms of kilogram made tea per hectare (KMTH), to even out cost variations due to mandays and quantity of input. The expenses were converted into kg made tea per hectare, taking Rs. 13 per kg as the average cost of production for the period 1979-80.

Table 12.04 *Replantation expenses for different regions during 1979-80 expressed as kilogram made tea per hectare (KMTH)*

Year	South Bank	North Bank	Dooars	Terai
—1	510	531	533	555
0	1419	1378	1516	1407
+1	529	522	653	600
+2	511	541	494	519
+3	418	388	485	418
Total	3387	3260	3681	3499

(c) **Yield after Replantation :** The yield pattern of young tea with age shows significant variation in different regions of the plains of N.E. India. It has also indicated substantial improvement in yield from 1969 onwards in all the regions. The yield pattern of 202 sections for different regions during 1961-68, 1969-72, 1973-78 and yields of the best section/sections in each region are shown in Fig 12.01.

(d) **Rate of Interest on Investment :** The rate of interest charged by the Tea Board under Tea plantation Finance Scheme, for replantation is 9$\frac{3}{4}$ percent less $\frac{1}{2}$ per cent rebate for prompt payment, 11% for loans advanced by ARDC and 18% by other financial institutions. Most of the estates avail Tea Board subsidy which is Rs. 10,400 per hectare paid in three

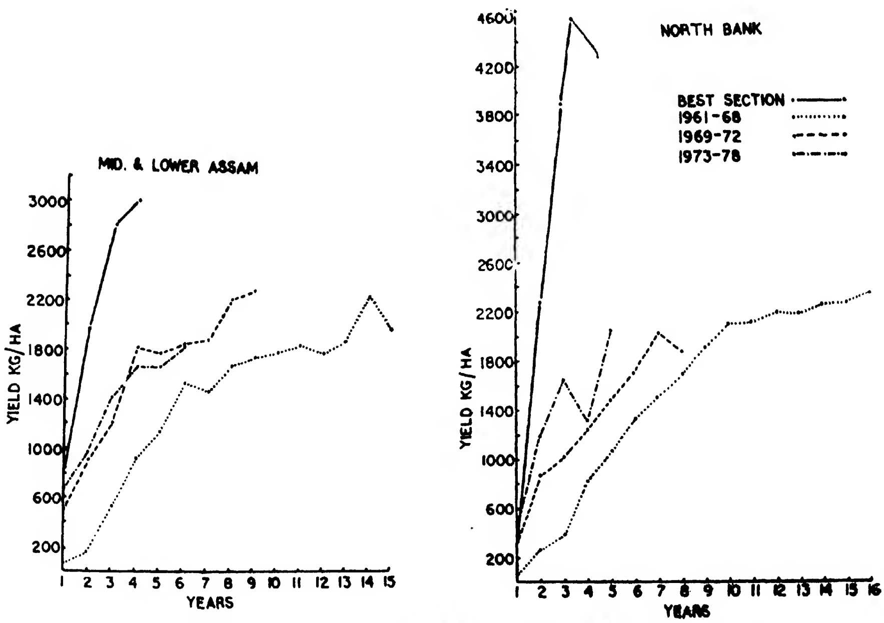


Fig 12.01. Yield Trends from section replanted covering 1961-68, 1969-72 and 1973-78

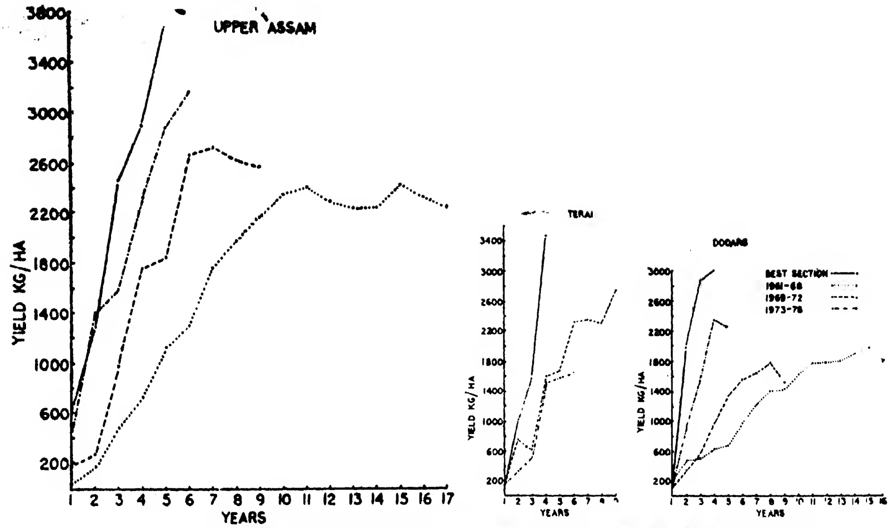


Fig 12.01. Yield trends from sections replanted covering 1961-68, 1969-72, 1973-78.

instalments for the plains of N.E. India. The impact of interest is more pronounced in case of replantation due to delay in recovery of the loss of yield from the uprooted sections. The Pay Back Period (PBP) with 11% and 18% rates of interest is shown in Fig. 12·02 and Fig. 12.03.

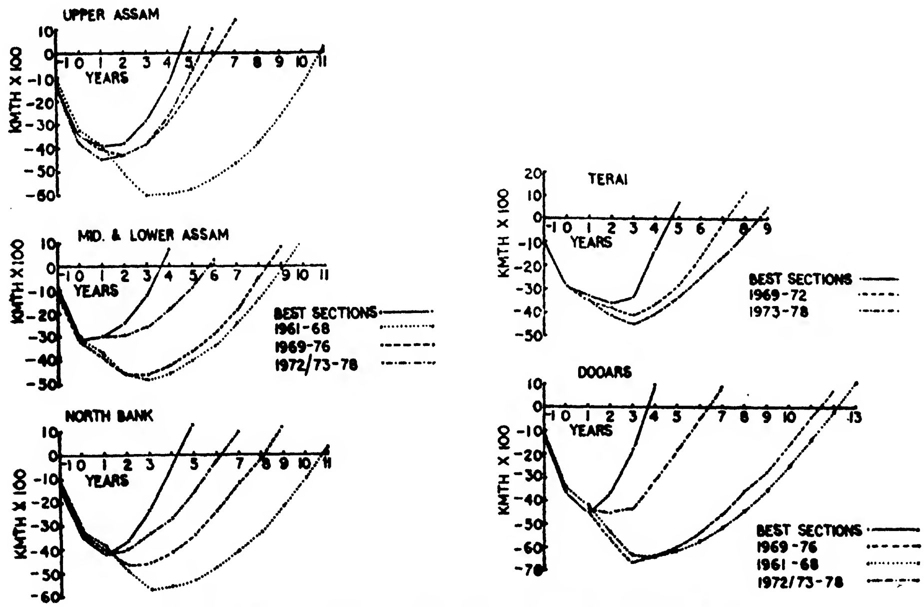


Fig 12.02. Replantation payback period in different region at 11% interest rate.

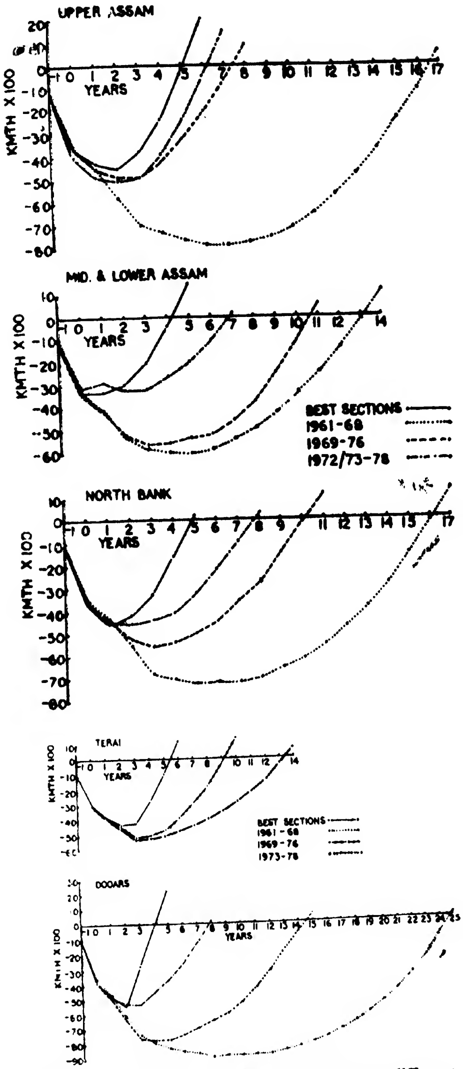


Fig 12.03. Replantation payback period on different region 18% interest rate.

Impact of yield on pay back period : Fig 12.01 shows the yield progression of young tea in different regions of N.E. India replanted during 1961-68, 1969-72 and 1973-78 together with the yield of the best sections in each region. The PBP for different regions with 11% and 18% rates of interest is given in Tables 12.05 and 12.06, respectively.

The cash flow has been shown under Figs 12.02 and 12.03 for 11% and 18% rate of interest with different patterns of yield for different regions of N.E. India.

Table 12.05. *Pay back period in years for replantation with 11% rate interest for different areas in the plains of N.E. India.*

Region	Replanted during 1961-68	1969-72	1973-78	Best section
Upper Assam (S.B.)	10.9	6.1	5.4	4.5
Middle and L. Assam (S.B.)	9.2	8.6	5.8	3.7
North Bank	10.7	8.2	6.3	4.2
Dooars	12.1	11.3	6.2	3.7
Terai	—	7.2	8.7	4.6

Table 12.06. *Pay back Period in years for replantation with 18% rate of interest for different areas in the plains of N.E. India.*

Region	Replanted during 1961-68	1969-72	1973-78	Best section
Upper Assam (S.B.)	16.7	7.4	6.2	5.1
Middle & L. Assam (S.B.)	13.1	10.7	7.0	4.3
North Bank	16.2	10.1	7.8	5.1
Dooars	24.2	14.6	8.0	4.1
Terai		9.2	13.4	5.4

Impact of interest on pay back period : The impact of increase in the interest rate by 7% from 11% to 18% on PBP in different regions and at different times is shown in Table 12.07. These figures are drawn from Table 12.0.5 & Table 12·06

Table 12.07. *Increase in the number of years, , the pay back period due to increase in the rate of interest from 11% to 18% for different replanting periods and for different regions in the plains of N.E. India.*

Region	Replanting period 1961-68	1969-72	1973-78 Average	Best section
Upper Assam	5.8 years	1.3 years	0.8 years	0.6 years
Mid & Lower Assam	3.9 ,,	2.1 ,,	1.2 ,,	0.6 ,,
North Bank Assam	5.5 ,,	1.9 ,,	1.5 ,,	0.9 ,,
Dooars	11.1 ,,	3.3 ,,	1.8 ,,	0.4 ,,
Terai		2.0 ,,	4.7 ,,	0.8 ,,

(e) Impact of increase in the amount of Tea Board subsidy on PBP : With the increase in the amount of subsidy from Rs. 4000/- to Rs 10,400/- per hectare in the plains of N.E. India, the PBP is reduced approximately by 4 months to 11 years depending upon the yield trend of the replanted sections at the current level of prices. One would expect the industry to take advantage of this increased subsidy by replanting at a faster rate before replanting cost escalation wipes out the benefit derived from the increased subsidy.

Comparative study of extension planting and replanting : Comparison of the results of extension planting published in Tocklai Ann. Rep., 1979-80, pp 85-89 with these results on replanting, shows the former to be more advantageous in having a shorter pay back period (PBP) due to the following reasons :

(a) Lower cost of extension than replantation
(b) No crop loss in extension due to uprooting
(c) Higher yield pattern of extension planting in virgin soils

(d) Lower interest burden due to lower cost and higher yield

Progress of extension and replantation : The progress of extension planting and replanting for the whole of N.E. India has been very slow during the sixties and the seventies. A sample of TRA estates was studied for comparative performances in replanting and extension. The data in Table 12.08 show the progress of extension in 83 member estates and replantation in 69 estates since 1961 in the plains of N.E. India. The average figures for all estates in the plains of N.E. India are taken from Tea Board statistics.

Table 12.08. *Progress of extension and replantation since 1961 in the whole of N.E. India and in the samples of member estates. Figures in brackets indicate the number of estates sampled.*

	Per cent area under extension in		Per cent area under replantation in	
Year	N.E. India	Sampled estates	N.E. India	Sampled estates
1961	0.87	2.49 (29)	0.73	2.64 (19)
1962	1.22	3.50 (29)	0.79	3.02 (18)
1963	1.41	3.78 (31)	0.74	2.44 (21)
1964	1.46	3.18 (38)	0.77	2.52 (21)
1965	1.96	4.66 (35)	0.74	1.96 (26)
1966	1.62	3.71 (44)	0.53	1.84 (20)
1967	1.43	2.62 (46)	0.55	1.59 (24)
1968	1.32	2.73 (46)	0.64	2.22 (20)
1969	1.16	2.23 (43)	0.50	1.56 (22)
1970	0.77	1.87 (34)	0.68	1.62 (28)
1971	1.06	2.32 (88)	0.88	1.83 (33)
1972	1.10	2.22 (41)	0.64	1.44 (31)
1973	1.01	2.16 (39)	0.61	1.56 (27)
1974	1.00	2.18 (38)	0.80	2.13 (26)
1975	1.72	2.10 (48)	0.68	1.73 (27)
1976	1.18	1.89 (52)	0.71	2.05 (24)
1977	1.09	1.74 (51)	1.75	2.06 (25)
1978	1.73	2.81 (51)	1.16	2.76 (29)

Extension planting has been ranging between 0.87% and 1.73% and replantation between 0.50% and 1.75% per year during the last 18 years in the whole of N.E. India. Among the 83 TRA member estates of the sample, the area under extension ranged between 1.87% to 3.78% and replantation between 1.56% to 2.76% per year during the last 18 years.

Cost of Manufacturing Operations : The study was undertaken in five tea estates of South Bank, Assam in order to (i) assess the cost of different operations in tea manufacture (ii) locate the major variations in cost, if any, between similar operations in different estates (iii) find out the factors responsible for such variations and (iv) suggest remedial measures where necessary. Four rounds of observations were taken in each of the five factories during the months of August and September, 1980.

Although the detailed study is not yet complete, the results obtained so far are summarised in Tables 12.09 and 12.10. For analysis only the direct costs of labour, and fuel were taken into consideration.

Table 12.09. *Total quantity of tea made during 1980 in the five observed estates in kilograms.*

Estate	C.T.C.		Orthodox		Total
	Quantity	Per cent of total	Quantity	Per cent of total	
A	9,65,257	80	2,39,900	20	12,05,157
B	13,36,711	89	1,65,289	11	15,02,000
C	4,51,492	62	2,76,382	38	7,27,874
D	3,82,913	32	8,19,896	68	12,02,809
E	3,59,523	40	5,451,67	60	9,04,690

Table 12.10. *Cost of manufacturing operations in rupees per kilogram of made tea.*

Operations	Items of expenditure	Estate				
		A	B	C	D	E
Withering	Labour	0.17	0.05	0.06	0.10	0.10
	Fuel	0.31	0.24	0.31	0.21	0.32
Rolling & sifting	Labour	0.05	0.04	0.08	0.11	0.25
	Fuel	0.02	0.03	0.20	0.13	0.37
C T C.	Labour	0.02	0.03	0.04	0.14	0.05
	Fuel	0.07	0.11	0.11	0.10	0.11
Fermentation	Labour	0.05	0.03	0.02	0.06	0.09
	Fuel	—	0.01	0.04	—	0.05
Drying	Labour	0.03	0.04	0.05	0.04	0.13
	Fuel	0.82	0.58	0.47	0.12	0.16
Sorting & grading	Labour	0.05	0.05	0.13	0.16	0.08
	Fuel	0.03	0.02	0.03	0.02	0.02
Packing	Labour	0.05	0.03	0.07	0.04	0.08
	Fuel	—	—	—	—	—
Total	Labour	0.42	0.27	0.45	0.68	0.68
	Fuel	1.25	1.00	1.16	0.58	1.38
Grand total		1.67	1.27	1.61	1.26	2.01

Note : Power cost was apportioned on the basis of Horse Power of the machinery. The cost of fuel was available separately for drying and withering operations in estates A & B from their records, on the basis of which apportionment was done for other estates.

Certain observations made in the course of this study are briefly discussed below under different manufacturing operations in an attempt to explain some of the observed differences in operational cost between estates.

Withering : The high labour cost in estate A can be attributed to its different withering system and lower load of leaf carried by the labourers. In the other estates a basket load of 16 to 25 kg leaf is carried by the labourers, while in estate A the load weighs only 8—12 kg.

Low fuel cost of estate B could be due to bigger size of some of the withering troughs, each having a capacity of about 3000 kg fresh leaf against 1500 kg in standard troughs which, in turn, reduced the cost of power and fuel. Fuel cost is the lowest in estate D which uses natural gas from the neighbouring ONGC field.

Rolling and sifting : Estates A and B manufacture predominantly C.T.C. teas while estates C and D are predominantly orthodox. The orthodox system of manufacture requires more labour than C.T.C. as reflected in Table 12.10. In estate E the distance between the withering troughs and rolling table is sufficiently long to make significant impact on labour cost.

A centrally driven shaft operating in estate E causes wastage of power and fuel and inflates the fuel cost. Among the estates C, D and E making a high percentage of orthodox tea, fuel cost is least in D as it utilises natural gas. Power and fuel cost is very low in the two C.T.C. estates A and B.

C.T.C. Manufacture : The labour cost in estate D was higher as they manufactured four fine C.T.C. grades which required hard cut and more labour for the operation, the out-put being only 300 kg per hour.

The power and fuel cost was more or less the same in all estates. Estate D using natural gas could have saved more had it used higher capacity C.T.C. machines.

Fermentation : Estate E engaged more labour in rack fermentation. The estate also engaged more labour to carry the leaf from three different sifters to the fermenting room. Estates B and C used minimum labour as they used trough fermentation and the rollers and C.T.C. machines were located very near to the fermentation troughs. The power and fuel costs in estate C and E were high as they used humidifiers of high horse power.

Drying : The labour cost in drying was high in estate E due to low output of the dryers in the estate. Increased drying time necessitated utilisation of more labour.

Power and fuel cost in estate A was hig[illegible]use the estate used T.D. oil in all the dryers and indirect firing in three of the six dryers. In estate D power and fuel cost was low due to availability of cheap natural gas.

Estate C used coal only for drying. Estate B used coal in four and T.D. oil in three dryers. Estate E used oil in one dryer and coal in four dryers.

Sorting and Grading : Labour cost of sorting in estate D was very high, the main reason being defective layout of the sorting room. To and fro movement of the workers between the ground and the first floor was time consuming.

There is much scope of reducing the labour cost of sorting and grading by following systematic layout of the sorting equipment and better supervision.

Power and fuel cost did not show much variations.

Packing : Labour cost of packing was high in estates C and E mainly due to the methods adopted by the estates in making payment for packing tea.

Tea Economics Courses : Two courses of 4 days duration on Tea Economics were conducted during August, 1980. 23 Managers and Assistant Managers participated in the course. In both courses, each lecture was followed by discussion and a case study based on actual problem. The faculty consisted of Dr. N.K. Jain, Director, Mr. S.R. Sengupta, Director, Jokai (India) Ltd. Mr. N.S. Venkatakrishnan, Cost Advisor, Dr. R.C. Awasthi, Agricultural Economist and Mr. A.K. Bhargava, Estate Manager.

Appendix-A

LIST OF EXPERIMENTS CONDUCTED IN THE MEMBER ESTATES BY ADVISORY DEPARTMENT 1981

SOUTH BANK

Project	Site	Index No.F	Year of Starting
NPK manuring of mature tea	Panitola	AS 108	1973
-Do-	Thowra	AS 111	1973
-Do-	Rupai	AS 114	1973
-Do-	Diffloo	AS 120	1973
-Do-	Meleng	AS 142	1976
Foliar application of zinc	Panitola	AS 109	1973
Shade in relation to tea nutrition	Thowra	AS 110	1973
-Do-	Bordubi	AS 113	1973
-Do-	Methoni	AS 119	1973
Rejuvenation Experiment	Tara	AS 128	1974
-Do-	Teloijan	AS 130	1974
-Do-	Dilli	AS 160	1978
Cultivation Experiment	Deohall	AS 134	1975
Young Tea Manuring (YTD)	Fatikjan	AS 144	1976
-Do-	Meleng	AS 145	1977
Young Tea Manuring (Response) Surface-NPK)	Balijan N	AS 153	1979
-Do-	Sepon	AS 161	1979
New Plucking Experiment (UP)	Nahortalli (Nahorhabi Sec)	AS 170	1979
-Do- (LP)	-Do- (Killybari Sec)	AS 171	1979
Micronutrient Trial	Dilli-18	AS 154	1977
	Dilli-5	AS 155	1977
	Dilli-9	AS 156	1977
	Daimukhia-9	AS 157	1977
	Daimukhia-5	AS 158	1977
	Daimukhia-13	AS 159	1977
	Meleng	AS 162	1977
	Sycotta	AS 163	1977
	Dhekiajulli	AS 166	1977
	Bokakahat	AS 166	1977
	Methoni	AS 167	1977
	Cinnamara	AS 185	1980
Times of Pruning/Skiffing	Daimukhia	AS 173	1980
	-Do-	AS 174	1980
	-Do-	AS 175	1980
	Hatikhulli	AS 176	1980
	Do-	AS 177	1980
	-Do-	AS 178	1980

NORTH BANK, ASSAM

Project	Site	Index No.F	Year of Starting
NPK manuring of mature tea	Monabarrie	AN 116	1973
-Do-	Naharani	AN 123	1973
Shade in relation to level tea nutrition	Partabgarh	AN 118	1973
Rejuvenation	Baghmari	AN 137	1974
-Do-	Baghmari	AN 141	1974
Nitrogen with and without mulch	Sessa	AN 138	1975
Micronutrient Trial	Durrang-IB	AN 146	1977
-Do-	Darrang-IA	AN 147	1977
-Do-	Singrijan	AN 148	1977
-Do-	Tarajullie-2	AN 149	1977
-Do-	Tarajullie-28	AN 150	1977
-Do-	Tarajullie-19	AN 151	1977
Spacing Trial	North Bank HQ	AN 152	1977
New Plucking Trial (UP)	Hattibari	AN 168	1979

SOUTH BANK

Project	Site	Index No.F	Year of Starting
SECTION. 22			
		AN 169	1979
Biclonal Seed Trial	NB HQ	AN 172	1979
Long term agricultural trial	HQ	AN 179	1980
Times of Pruning/Skiffing	Dekorai	AN 180	1980
	-Do-	AN 181	1980
	Dhekiajullie	AN 182	1980
	-Do-	AN 184	1980

CACHAR

Project	Site	Index No.F	Year of Starting
NPK manuring of mature tea	Silcoorie	C 38	1973
-Do-	Longai	C 39	1973
Rejuvenation Experiment	Isabheel	C 47	1974
Young Tea Manuring (YTD)	Borjallingah	C 49	1977
Young Tea Manuring (YTD) (Response surface-NPK)	Arcuttipore	C 50	1977
Bringing up of young tea (Studies on frame development)	Arcuttipore	C 51	1977
Micronutrient Trial	Isabheel-4	C 52	1977
	Isabheel-7	C 53	1977
	Isabheel-11	C 54	1977
Spacing Trial	Borjallingah	C 55	1977
New plucking trial (LP)	West Jallingah	C 56	1979
SECTION. 2			
-Do- (UP)	West Jallingah	C 57	1979
Times of Pruning/Skiffing	Arcuttipore	C 58	1980
	Do-	C 59	1980
	Do-	C 60	1980
	Derby	C 61	1980
	-Do-	C 62	1980
	Do-	C 63	1980

DOOARS & TERAI (WEST BENGAL)

Project	Site	Index No.F	Year of Starting
NPK manuring of mature tea	Bagrakote	D 55	1973
-Do-	Samsing	D 56	1973
-Do-	Nimtijhora	D 57	1973
-Do-	Gungaram	TR 7	1973
Clonal response to N in different agro-climatic region	Nya Sylee	D 24	1962
Shade in relation to level of tea nutrition	Gandrapara	D 50	1973
	Satali	D 78	1978
Rejuvenation Experiment	Dalgoan	D 43	1972
	Metalli	D 44	1972
	Rydak	D 46	1972
	Kumtai	D 47	1972
	Gungaram	TR 5	1972
Clone Vs Nitrogen Trial	Nagrakata	D 48	1973
Long term Trial	Nagrakata HQ	D 61	1974
New long term trial	-Do-	D 62	1975
Young tea manuring (YTD)	-Do-	D 65	1977
-Do-	Nagaisurrie	D 66	1977
Young tea manuring (Response surface-NPK)	Rydak	D 67	1978
-Do-	Lakhipara	D 68	1977
-Do-	Bhogotpore	D 69	1978

SOUTH BANK

Project	Site	Index No. F	Year of Starting
Bringing up of young tea Micronutrient Trial	Haldibari	D 70	1977
	Bharnabari-5	D 71	1977
	Bharnabari-6	D 72	1977
	Bharnabari-7A	D 73	1977
	Grassmore	D 74	1977
	Nagrakata	D 75	1977
	Bhogotpore	D 76	1977
Spacing Trial	Nagrakata HQ	D 77	1977
Plucking round Trial	Bhogotopore (UP)	D 79	1978
	-Do- (LP)	D 80	1978
	Hansqua (UP)	TR 81	1978
	-Do- (LP)	TR 82	1978
Times of Pruning/Skiffing	Baradighi	D 83	1980
	-Do-	D 84	1980
	-Do-	D 85	1980
	Sahabad	TR 86	1980
	-Do-	TR 87	1980
	-Do-	TR 88	1980
	Gopalpur	D 89	1980
	-Do-	D 90	1980
	-Do-	D 91	1980

SOUTH BANK

Project	Site	Index No. F	Year of Starting
NPK Manuring of mature tea	Choongtong	Dj 34	1973
-Do-	Nagrifarm	Dj 35	1973
Clonal response to N in different Climatic region	Nagrifarm	Dj 19	1961
Young tea manuring	Gielle	Dj 48	1978
Young tea manuring (Response surface- NPK)	Phoobsering	Dj 47	1978
Micronutrient Trial	Ringtong	Dj 43 & 44	1978 1977
	Balsun	Dj 45 & 46	1977 1977
	Goomte	Dj 41 & 42	1977 1977
	Maharcai	Dj 40	1977
Times of Pruning/Skiffing	Teestavalley	Dj 49	1980
	Salimbong	Dj 50	1980
	-Do-	Dj 51	1980

Appendix - B

LIST OF EXPERIMENTS CONDUCTED IN THE MEMBER ESTATES BY THE OTHER DEPARTMENTS

PLANT PROTECTION DEPARTMENT

I. MYCOLOGY

Sl. No.	Experiment	Location	Site	Index No.	Year of Starting
1.	Evaluation of different formulation against red rust	S. Bank	Heeleakah	MR 032	1980
2.	Effect of fungicidal control of red rust on yield return	,,	Boisahabi	MR 031	1980
3.	Testing of new fungicides against thorny stem blight	Darjeeling	Happy Valley	MC 006	1975
4.	Screening of fungicides against black rot	S. Bank	Sycotta	MB 025	1980
5.	Screening of fungicides against blister blight	Darjeeling	Marybong	MF 012	1980
6.	Intergrated control of blister blight	,,	Arya	MF 013	1980
7.	Screening trial against red spot disease	,,	Rungneet	MS 002	1980
8.	Chemical control of primary root disease	S. Bank	Nahorkutia	MP 002	1974
9.	,,	,,	Borhat	MP 005	1975
10.	,,	N. Bank	Tarajulie	MP 004	1975
11.	,,	,,	Thakurbari	MP 006	1975
12.	,,	Darjeeling	Balasun	MP 003	1974
13.	,,	S. Bank	Dilli	MP 007	1976

II ENTOMOLOGY

1.	Chemical control of termites in tea	Cachar	Borjalingha	1979
2.	Chemical control of termites in tea	Cachar	Bhubandhar	1979
3.	Biology and control of shade tree pests	S. Bank	Dooria	1980
4.	Black scale biology and control study	S. Bank	Dooria	1977
5.	Chemical control of red spider with new formulations	S. Bank	Tocklai Botanical Plot	1980
6.	Chemical control of red slug caterpillars	Dooars	Gurjanjhora	1980
7.	Chemical control of cockchafer	Dooars	Mannabari	1980
8.	Thrips control trial	Dooars	Soongachi	1980
9.	Thrips control trial	Dooars	Binnaguri	1981
10.	Thrips control trial	Dooars	Binnaguri	1980
11.	Thrips control trial	S. Bank	Katalgoorie	1980
12.	Incidence of mites in relation to micronutrients	S. Bank	Meleng	1978
13.	Incidence of mites in relation to micronutrients	S. Bank	Sycotta	1978

SOILS & METEOROLOGY

1.	Sub-surface drainage experiment	Hunwal
2.	,, ,, ,, ,,	Mogulkata
3.	,, ,, ,, ,,	Haroocharai
4.	Pump ,, ,,	Haroocharai
5.	Pump ,, ,,	Lengrai

ENGINEERING R & D

1.	Trial of 45cm, 40cm and 37cm Boruah Continuous Rollers for 1st and 2nd roll (orthodox)	Hunwal (Mariani)

STATISTICS

1.	Uniformity Trial	(Darjeeling,)	Nagri Farm	1964

Appendix

PUBLISHED PAPERS & PAPERS IN THE PRESS

Basu, S.D., Gope, B. & Banerjee, B. 1981. Effect of light of different wave lengths on soil extraction of *Meloidogyne incognita* by Improved Baerman Funnel method (abstr.). *Indian J. Nematol.* 11, pp. 104-105.

(Abs. Improved Baerman Funnel technique under exposures to artificial light significantly increases extraction of root-knot nematodes from soil, though amongst themselves, lights of different wave lengths did not show any significant difference in their effects on extraction efficiency. Exposures of light for 4 hours and 24 hours significantly influenced the extraction efficiency).

Dev Choudhury, M.N. & Bajaj, K.L. 1980. Quantitative changes of amino acids water-soluble sugars and chlorophylls during processing of tea leaf and their relation with tea quality. *Proc. of Second Federation of Asiatic & Oceanic Congress & Golden Jubilee of SBC, Indian Instt. of Sc.*, Bangalore. pp. 146.

(Abs. Black teas are made from green tea shoots by subjecting them to withering fermentation and firing. During withering except theanine (N-ethyl glutamine) which decreased, all other amino acids increased, water-soluble sugars and chlorophylls decreased. During fermentation except aspartic and glutamic acids, other amino acids decreased with the formation of the corresponding aldehydes; reducing sugars increased at the expense of non-reducing sugars and chlorophylls were partly broken down to pheophorbides and pheophytins. Firing caused a decrease in the levels of amino acids, sugars and chlorophylls and increase in the pheophytin content. High levels of amino acids, sugars and chlorophylls appeared detrimental to tea quality but phenylacetaldehyde derived from phenylalanine and pheophytins from chlorophylls contributed to the quality of N.E. Indian plains teas).

Dev Choudhury, M.N., Ravindranath, S.D. & Jain, N.K. 1980. Tea Manufacture. Abstract of papers of Third Annual Symp. on *Plantation Crops*, held at Cochin. pp. 10a.

(Abs. Black tea is manufactured from two leaves and bud of *Camellia sinensis* O. Kuntze by Orthodox and CTC methods through intermediate stages, namely withering, rolling, fermentation and firing. During withering, partly proteins are broken down to amino acids, sugars to amino acids and CO_2 and chlorophylls to chlorophyllide. Besides, caffeine, volatile compounds and inorganic phosphorus increase. Rolling facilitates the mixing of enzymes and various substrates. During fermentation polyphenols are oxidised to theaflavins and thearubigins, amino acids are partly converted to aldehydes, carotenes are degraded forming ionones, linalools and their oxides and chlorophylls are transformed to pheophorbides and traces of pheophytins. Firing causes denaturation of enzymes and degradation of chlorophylls to form pheophytins. Generally good quality tea is a balance of theaflavins, thearubigins, caffeine, degradation products of chlorophylls (pheophytins) and flavouring components. Various machines developed for withering, rolling, fermentation and firing, new lining materials, alternative uses of teas like instant tea, lemon tea and tea cola have been reported. Chemical tests for ascertaining adequate fermentation and methods for detecting correct manufacture have also been briefly reported.)

Ravindranath, S.D., Venugopala Reddy, A.R., Balakrishnan, C.V., Sobhanaditya, J., Ananthanarayanan, V.S. & Appaji Rao, N. Deptt. of Biochem., & Molecular Biphysics Unit, I.I.Sc., Bangalore. Comparison of the conformation and stability of the native dimeric, monomeric, tetrameric & the desensitized forms of the nucleotide pyrophosphatase from mung bean (Phaseolus aureus) seedlings. *J. Biosci.* 2(3), Sept 1980. pp. 211-225.

(Abs. A homogenous and crystalline form of nucleotide pyrophosphatase (EC 3.6.1.9) from Phaseolus aureus (mung bean) seedlings was used for the study of the regulation of enzyme activity by adenine nucleotides. The native dimeric form of the enzyme had a helical content of about 65% which was reduced to almost zero values by the addition of AMP. In addition to this change in the helical content, AMP converted the native dimer to a tetramer. Desensitization of AMP regulation, without an alteration of the molecular weight, was achieved either by reversible denaturation with 6 M urea or by passage through a column of Blue Sepharose but addition of p-hydroxymercuri-benzoate desensitized the enzyme by dissociating the native dimer to a monomer. The changes in the quaternary structure and conformation of the enzyme consequent to AMP interaction or desensitization were monitored by measuring the helical content, EDTA inactivation and Zn + reactivation, stability towards heat denaturation, profiles of urea denaturation and susceptibility towards proteolytic digestion. Based on these results and our earlier work on this enzyme, we propose a model for the regulation of the mung bean nucleotide pyrophosphatase by association-dissociation and conformational changes. The model emphasizes that multiple mechanisms are operative in the desensitization of regulatory proteins.

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1980

Table 1. Tocklai Experimental Station

Station : Tocklai   Longitude : 94°12'E   Latitude 26°47'N   Elevation 96.5 m a.m.s.l.

Months	Temperature in °C						Rainfall mm		Days with Rain 0.3 mm& above	Sunshine hrs		Wind speed (Km)		Soil Temperature °C BARE					
														at 0613 hrs (IST)			at 1313 hrs (IST)		
	Mean daily max	Mean daily min	Normal Max	Normal Min	Highest Max	Lowest Min	Total mon.	Normal		Mean daily	Normal	Mean daily	Normal	5 cm	15 cm	30 cm	5 cm	15 cm	30 cm
Jan.	21.7	10.0	22.3	9.4	23.3	7.0	30.8	21.2	2	6.3	5.9	20.9	20.3	14.4	15.7	17.9	20.9	17.9	17.8
Feb.	23.0	11.9	24.1	11.9	26.1	8.1	56.7	31.8	10	6.8	6.3	34.9	36.5	15.6	17.0	18.9	22.5	19.4	18.8
Mar.	25.9	16.4	27.6	15.5	30.8	12.0	86.2	78.0	16	6.8	6.7	38.3	52.8	19.5	20.5	21.9	26.5	23.2	21.9
April	28.1	20.4	28.7	19.1	32.7	17.8	260.8	192.9	21	6.6	5.9	45.5	59.9	23.8	24.5	24.3	30.0	26.9	25.7
May	29.4	22.4	29.9	21.9	33.6	20.5	278.6	280.6	25	4.6	5.0	39.1	52.6	25.8	26.0	27.0	31.9	28.0	27.0
June	32.5	25.3	31.5	24.2	35.6	23.5	225.7	328.5	18	5.9	4.5	43.0	55.0	28.5	29.0	29.9	35.2	31.6	30.0
July.	33.2	25.5	32.2	24.7	36.4	24.5	413.5	382.8	23	6.7	4.8	51.0	59.1	29.3	29.8	30.9	36.1	32.4	31.0
Aug.	32.3	25.3	32.0	24.6	35.8	23.2	411.6	343.0	24	5.2	5.1	45.1	49.9	28.8	29.4	29.5	35.0	31.6	29.6
Sep.	31.8	24.7	31.2	23.9	35.1	21.7	320.3	252.8	20	6.2	5.1	36.2	40.6	27.2	28.7	30.0	35.4	31.3	30.2
Oct.	29.0	21.0	29.3	21.0	31.7	17.3	135.9	119.0	11	6.0	5.7	24.8	29.5	24.2	25.2	26.9	30.4	27.8	27.1
Nov.	27.6	14.7	26.3	15.3	29.3	11.3	1.1	28.1	2	7.9	6.1	18.2	20.3	19.2	20.9	23.0	29.1	24.9	23.8
Dec.	25.2	10.9	23.4	10.6	26.7	9.5	0.0	11.0	0	7.5	6.1	13.2	13.2	15.7	18.1	20.0	25.4	20.9	19.9

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1980

Table 2. Silcoorie

Station : Silcoorie   Longitude : 92° 48'E   Latitude : 24 °50'N   Elevation 39.6 a.m.s.l.

Month	Temperature in °C						Rainfall mm		Days with Rain 0.3 mm & above	Sunshine hrs		Wind speed (Km)		Soil Temperature °C BARE					
														at 0619 hrs (IST)			at 1319 hrs (IST)		
	Mean daily Max	Mean daily min	Normal Max	Normal Min	Highest Max	Lowest Min	Total mon.	Normal		Mean daily	Normal	Mean daily	Normal	5 cm	15 cm	30 cm	5 cm	15 cm	30 cm
Jan.	24.5	11.1	25.7	10.4	26.8	8.2	6.4	15.4	1	8.1	8.5	31.9	38.0	16.4	19.4	21.4	26.7	21.5	21.7
Feb.	26.6	12.9	27.5	12.8	30.4	7.7	97.2	48.9	5	8.5	8.3	61.8	60.7	17.8	20.9	?	28.9	23.5	?
Mar.	28.3	17.7	30.6	16.6	32.5	12.7	133.2	109.0	11	7.7	8.1	68.1	80.6	21.1	23.7	26.0	31.5	26.2	26.5
April	31.0	21.2	31.6	20.5	33.7	17.2	328.7	287.0	15	8.6	7.7	68.4	90.8	24.5	26.7	28.5	34.6	29.4	29.1
May	29.3	22.0	31.6	22.7	33.7	18.8	6664.4	403.7	26	6.1	6.8	60.2	78.5	25.4	26.7	28.5	32.6	29.2	28.9
June	31.7	22.7	31.5	24.3	33.6	22.8	92.0	598.0	29	5.9	4.5	60.5	67.9	28.1	29.1	30.8	35.2	32.0	31.3
July	32.3	25.7	32.0	24.9	35.6	24.2	303.8	516.6	27	5.5	4.5	60.2	68.6	28.7	30.0	31.9	35.9	32.8	32.4
Aug.	32.0	25.5	33.1	24.9	34.9	24.2	453.5	427.1	25	6.1	5.0	49.9	58.7	28.2	29.6	31.6	36.2	32.7	32.0
Sep.	31.3	25.0	32.2	24.4	35.6	23.2	454.9	337.5	19	5.7	5.8	43.6	55.0	27.7	29.0	31.0	34.3	31.8	31.5
Oct.	29.9	22.4	31.2	22.4	32.9	18.8	182.2	194.7	10	6.6	6.7	29.8	40.7	25.5	27.1	29.9	32.9	30.0	29.5
Nov.	30.2	17.2	29.2	17.5	31.9	13.5	0.0	35.2	0	9.2	7.8	23.7	35.4	22.3	24.6	26.9	33.4	28.6	27.7
Dec.	27.6	13.3	26.8	12.5	29.1	10.8	0.3	10.2	1	8.5	8.1	21.1	32.3	18.5	21.2	23.5	29.3	24.6	24.1

Appendix - D

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1980

Table 3. Nagrakata

Station : Nagrakata Longitude : 88°32′E Latitude : 26°54′ N Elevation 228.6 a.m.s.l.

Months	Temperature in °C						Rainfall mm		Days with Rain 0.3 mm & above	Sunshine hrs		Wind speed (Km)		Soil Temperature °C BARE					
														at 0634 hrs (IST)			at 1334 hrs (IST)		
	Mean daily Max	Mean daily Min	Normal Max	Normal Min	Highest Max	Lowest Min	Total mon.	Normal		Mean daily	Normal	Mean daily	Normal	5 cm	15 cm	30 cm	5 cm	15 cm	30 cm
Jan.	22.6	10.7	23.5	10.5	24.0	7.1	7.4	10.5	1	7.7	7.7	53.4	81.9	13.3	17.3	19.1	24.6	18.9	19.2
Feb.	24.7	11.4	25.3	12.7	28.7	9.0	31.9	25.7	5	6.4	7.0	63.2	94.8	16.0	19.4	20.5	27.0	21.4	20.9
Mar.	27.4	16.0	29.4	16.3	32.2	11.0	141.2	39.7	10	7.6	7.7	82.7	112.0	18.7	21.7	23.0	29.0	23.6	23.2
April	31.6	20.9	31.0	20.1	33.9	17.5	110.6	143.7	12	7.9	7.0	112.5	121.5	23.4	26.6	27.4	35.3	29.1	29.3
May	29.5	21.4	30.6	21.7	32.1	18.7	386.4	336.5	21	5.6	6.5	85.9	108.0	24.0	26.1	28.1	32.1	28.0	28.3
June	30.8	24.1	30.5	23.8	33.6	22.5	598.1	859.0	24	5.5	4.1	74.0	86.1	26.0	28.3	28.1	33.6	30.1	28.2
July	30.6	24.2	30.4	23.9	34.0	22.9	912.9	1016.0	28	3.2	3.4	74.5	81.3	26.9	28.6	29.6	32.9	29.8	29.7
Aug.	30.7	23.9	30.8	23.8	34.2	22.9	616.6	742.0	27	4.6	4.2	60.8	77.2	26.7	28.5	29.6	33.4	29.9	29.6
Sep.	31.4	23.4	30.6	22.8	36.1	22.0	737.2	572.4	22	5.7	5.1	55.4	69.7	26.0	28.0	28.0	33.4	29.9	29.6
Oct.	29.5	19.5	29.8	19.6	31.9	15.6	63.6	222.4	10	8.1	7.7	62.0	68.1	22.6	25.2	27.1	31.2	27.4	26.3
Nov.	28.6	15.4	27.4	15.0	30.0	7.4	0.0	24.4	0	9.7	8.4	58.1	71.6	18.7	22.5	24.7	31.7	25.3	24.9
Dec.	25.9	12.6	24.8	11.7	27.2	11.3	0.0	6.0	0	8.0	8.3	52.3	73.7	16.4	20.4	22.1	28.5	22.5	22.3

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1980

Table 4. Nagrifarm

Station : Nagrifarm Longitude : 88°12′E Latitude : 26°55′N Elevation 1158.24 a.m.s.l.

Months	Temperature in °C						Rainfall mm		Days with Rain 0.3 mm & above	Sunshine hrs		Wind speed (Km)		Soil Temperature °C BARE					
														at 0637 hrs (IST)			at 1337 hrs (IST)		
	Mean daily Max	Mean daily Min	Normal Max	Normal Min	Highest Max	Lowest Min	Total mon.	Normal		Mean daily	Normal	Mean daily	Normal	5 cm	15 cm	30 cm	5 cm	15 cm	30 cm
Jan.	14.5	7.4	15.0	7.8	16.4	6.3	0.0	17 [illegible]	0	5.8	6.0	92.2	93.3	7.5	8.8	?	17.7	13.4	?
Feb.	15.8	9.0	16.7	9.4	20.2	4.9	0.0	20.7	0	4.4	5.8	95.1	106.1	9.4	11.3	?	18.7	14.8	?
Mar.	19.1	12.3	21.4	13.2	25.7	7.5	64.3	47.7	13	6.8	7.1	153.2	142.9	12.8	13.0	?	23.0	18.2	?
April	24.7	17.1	23.6	15.9	27.2	13.9	17.5	98.2	4	7.7	5.8	146.1	136.3	18.1	19.0	?	30.5	21.3	?
May	23.5	16.6	23.8	17.0	25.9	15.0	183.1	197.1	21	4.2	5.1	113.9	101.2	19.5	19.9	?	26.2	23.2	?
June	24.7	19.1	24.1	18.8	26.6	17.5	314.0	419.2	20	4.2	3.1	88.0	80.0	22.1	22.0	23.2	28.5	25.2	23.2
July	24.8	19.6	24.3	19.3	28.1	18.0	660.3	642.8	27	3.0	2.4	79.2	71.5	22.3	22.6	23.8	28.5	25.1	23.8
Aug.	25.0	19.3	24.8	19.2	27.4	18.6	423.3	459.5	25	4.2	3.4	78.7	71.3	18.1	22.8	24.6	29.0	25.7	24.6
Sep.	24.0	18.6	24.4	18.2	28.4	16.8	262.4	312.2	20	4.3	3.9	71.8	71.9	21.0	21.8	?	27.4	24.4	?
Oct.	23.1	15.1	23.2	15.7	25.2	13.5	130.4	138.6	6	7.3	6.6	80.1	77.4	17.2	18.6	?	27.7	22.9	?
Nov.	21.3	12.7	20.4	12.1	23.2	10.1	0.0	11.8	0	8.9	7.0	80.9	77.9	13.2	16.1	?	27.2	21.0	?
Dec.	18.7	10.3	17.5	9.3	20.6	9.2	0.0	9.2	0	7.0	6.8	78.2	80.8	10.4	13.4	?	22.3	17.7	?

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1980

Table 5. North Bank

Station : North Bank Longitude : 92°42′E Latitude : 26°48′N Elevation 92°45 m a.m.s.l.

Months	Temperature in °C						Rainfall mm		Days with Rain 0.3 mm & above	Sunshine hrs		Wind speed (Km)		Soil Temperature °C BARE					
														at 0619 hrs (IST)			at 1319 hrs (IST)		
	Mean daily Max	Mean daily Min	Normal Max	Normal Min	Highest Max	Lowest Min	Total mon.	Normal		Mean daily	Normal	Mean daily	Normal	5 cm	15 cm	30 cm	5 cm	15 cm	30 cm
Jan.	23.4	8.9	23.9	8.3	25.1	5.4	25.3	15.5	3	7.9	7.7	40.2	36.4	12.7	15.1	17.7	24.6	19.4	17.7
Feb.	25.0	11.9	26.1	11.2	29.1	7.0	35.0	14.0	6	7.6	7.5	72.8	64.0	15.0	17.1	19.0	25.7	21.3	21.1
Mar.	26.7	14.9	29.8	15.2	32.5	11.1	83.6	47.3	9	7.5	7.9	105.1	101.1	18.4	20.3	21.8	29.2	24.3	22.2
Apr.	29.3	19.4	30.5	19.5	34.5	16.5	33.5	152.8	2	8.0	6.8	119.3	123.2	23.3	25.1	26.3	34.2	29.3	26.6
May	29.7	21.5	30.9	21.9	32.8	19.9	92.0	229.3	12	4.5	5.9	71.1	67.7	24.1	25.3	26.5	31.5	28.2	26.8
June	32.4	24.8	31.9	24.4	35.8	23.3	593.1	460.0	20	5.2	4.8	58.4	68.4	27.5	28.0	29.3	34.9	30.8	29.6
Jul.	32.9	25.4	32.4	24.9	35.6	24.0	469.9	532.7	21	5.1	4.8	63.4	67.4	28.4	?	29.5	34.2	34.2	30.5
Aug.	32.3	25.1	32.6	24.9	35.9	23.7	359.8	292.8	20	4.7	5.3	64.6	59.8	27.7	28.8	28.1	34.7	31.3	29.4
Sep.	32.3	24.6	31.9	23.5	36.7	22.7	276.9	301.5	19	5.8	5.6	45.5	43.6	27.3	28.7	26.8	35.5	31.7	30.8
Oct.	28.6	20.5	30.3	20.3	32.8	16.1	53.2	142.5	7	7.3	7.1	35.4	33.5	23.2	25.2	26.9	33.5	29.8	28.6
Nov.	28.7	13.5	27.9	15.0	29.8	10.4	0.0	19.7	0	9.6	7.7	20.3	23.1	18.1	21.1	25.6	30.2	26.3	27.3
Dec.	26.5	10.3	25.0	9.7	28.0	7.6	0.0	17.2	0	8.5	8.1	23.0	24.2	15.1	?	?	25.6	22.2	?

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1980

Table 6. Dirok (Margherita)

Station : Dirok (Magherita) Longitude : 95°32 Latitude : 27°16′N Elevation 183m a.m.s.l.

Months	Temperature in °C						Rainfall mm		Days with Rain 0.3 mm & above	Sunshine hrs		Wind speed (Km)		Soil Temperature °C BARE					
														at 0608 hrs (IST)			at 1308 hrs (IST)		
	Mean daily Max	Mean daily Min	Normal Max	Normal Min	Highest Max	Lowest Min	Total mon.	Normal		Mean daily	Normal	Mean daily	Normal	5 cm	15 cm	30 cm	5 cm	15 cm	30 cm
Jan.	21.4	8.5	22.3	8.1	23.7	5.0	43.7	26.1	8	6.4	6.8	42.6	43.1	12.8	15.8	17.5	20.6	18.0	17.6
Feb.	22.5	10.9	23.7	10.3	26.3	6.4	87.2	52.5	13	6.0	6.7	53.9	53.3	14.6	17.0	18.4	22.1	19.0	18.5
Mar.	25.3	14.9	26.3	14.3	29.7	11.2	235.6	162.2	18	7.6	7.1	42.1	52.5	18.2	20.1	21.0	25.8	21.9	21.3
April	27.6	18.8	29.1	18.5	32.5	14.9	322.5	231.1	23	4.9	5.9	77.3	73.0	22.3	23.7	24.5	29.2	25.3	24.6
May.	29.6	20.7	30.2	21.1	32.6	18.5	256.0	234.7	21	4.7	5.2	45.6	49.5	25.1	26.1	26.8	31.1	28.0	26.0
June	32.5	24.1	33.2	23.9	35.0	22.2	658.2	441.8	22	5.2	5.6	43.9	45.9	28.3	28.9	29.5	34.8	30.7	29.6
July	31.7	24.7	31.3	24.5	36.5	23.1	375.3	479.8	24	3.7	3.2	44.3	46.4	29.0	29.9	30.4	34.1	31.2	30.5
Aug.	31.3	24.2	32.0	24.4	35.3	23.0	454.7	381.5	21	3.7	3.9	44.0	45.5	28.4	29.6	29.6	33.0	30.7	29.7
Sep.	31.3	23.4	30.9	23.4	35.2	21.5	463.0	423.4	20	5.2	5.0	103.4	71.8	27.8	29.0	29.5	33.5	30.6	29.5
Oct.	28.7	19.5	28.8	19.4	32.0	15.1	163.9	167.1	14	6.1	6.4	33.1	35.8	23.9	26.1	26.9	30.4	27.6	26.9
Nov.	26.8	12.7	26.9	14.5	29.9	10.0	2.1	11.5	1	8.7	7.3	30.0	30.8	18.9	21.8	23.5	28.0	23.9	23.6
Dec.	24.9	9.7	23.0	10.2	26.3	8.0	0.0	34.8	0	6.8	6.2	35.5	36.9	15.2	18.4	19.7	23.8	20.2	19.8

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1980

Table 7. Gungaram

Station : Gungaram   Longitude : 88°48'   Latitude : 26°33'   Elevation 123.6m a.m.s.l.

Months	Temperature in °C						Rainfall		Days with Rain 0.3 mm & above	Sunshine hrs		Wind speed (Km)		Soil Temperature °C BARE					
														at 0635 hrs (IST)			at 1335 hrs (IST)		
	Mean daily Max	Mean daily Min	Normal Max	Normal Min	Highest Max	Lowest Min	Total mon.	Normal		Mean daily	Normal	Mean daily	Normal	5 cm	15 cm	30 cm	5 cm	15 cm	30 cm
Jan.	22.8	9.1	23.3	9.1	24.3	7.1	0.0	1.0	0	8.4	7.9	56.6	51.9	12.2	15.4	17.4	23.6	18.0	17.6
Feb.	25.2	11.5	25.6	11.0	28.8	5.8	6.7	9.3	1	8.0	8.1	73.1	68.1	15.1	17.9	19.0	26.7	20.7	19.8
Mar.	29.2	15.8	30.5	14.8	34.4	11.1	45.4	22.9	4	8.2	8.9	102.6	100.3	20.2	22.4	23.0	32.7	24.5	26.3
April	34.1	20.8	32.2	20.5	36.0	14.8	20.4	73.8	3	8.9	8.4	108.1	119.1	25.7	27.4	29.5	36.1	33.5	—
May	30.6	21.9	31.1	22.2	32.8	18.6	254.6	245.8	18	7.5	7.4	103.8	99.2	25.4	27.5	28.5	33.2	30.4	29.4
June	31.5	24.6	31.7	23.7	33.8	23.2	507.6	358.0	21	6.8	6.6	77.1	89.0	27.8	29.0	29.4	34.8	31.3	30.2
July	31.1	24.8	30.9	24.8	34.1	23.3	850.0	839.1	28	4.9	4.8	79.3	78.1	27.8	29.6	?	33.6	30.9	?
Aug.	31.5	24.8	32.0	24.8	33.8	23.4	643.4	619.2	24	5.9	6.0	69.0	68.2	27.5	28.7	?	34.2	31.1	?
Sep.	31.5	24.1	31.3	23.9	33.8	22.1	415.6	406.2	22	5.9	5.8	43.1	53.7	27.0	27.9	?	30.9	30.9	?
Oct.	30.1	19.6	30.2	20.0	32.6	16.1	72.0	126.8	9	8.5	7.9	40.1	42.9	23.0	25.6	?	32.2	28.7	?
Nov.	29.3	14.4	28.1	15.9	30.9	11.0	0.0	40.0	0	9.4	8.0	27.8	37.4	18.0	23.3	?	31.1	23.5	?
Dec.	26.5	11.1	25.4	11.1	28.3	9.9	0.0	27.0	0	7.9	7.9	30.2	38.7	14.9	18.3	?	27.5	21.7	?

Table 8

Total monthly U.S. Pan Evaporation (mm) of N.E. India Tea Area during 1980

Area	Stations	January	Februry	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
Assam Valley South Bank	Tocklai	32.0	47.3	71.4	85.1	78.6	95.5	111.0	90.3	84.0	54.3	47.3	35.8
	Margheritta	35.9	45.9	65.0	71.7	80.6	73.6	70.5	56.5	57.6	61.0	58.8	38.2
	Kellyden	36.8	71-1	93-3	125.4	91.9	110.5	106.5	119.3	95.2	94.6	63.2	51.2
Assam Valley North Bank	Monabari	?	?	?	?	140.0	159.7	157.0	155.2	145.7	132.4	99.5	92.3
	Thakurbarie	51.7	73.1	103.9	116.0	97.3	99.6	102.1	91.9	86.0	82.5	63.0	50.1
	Julia	47.9	62.4	73.0	95.1	82.1	76.1	89.9	87.2	80.8	63.2	75.8	78.7
	Mornoi	56.4	65.1	113.0	137.0	119.1	108.0	151.1	117.3	84.1	80.6	62.9	45.9
Cachar	Silcoorie	59.3	83.5	84.2	100.6	89.6	89.8	92.0	78.6	71.8	77.6	74.1	60.7
	Hattikhira	56.2	82.0	114.4	134.1	121.4	126.2	117.0	100.6	83.2	81.8	72.0	60.1
	Kumber	?	?	?	122.4	128.?	117.3	133.5	112-4	101.9	86.1	70.0	61.0
North Bengal	Chuapara	?	?	?	122.4	125.3	116.1	96.5	104.0	89.3	90.4	71.9	56.6
	Nagrakata	54.8	71.3	123.7	151.8	127.1	126.0	112.5	121.2	108.4	96.8	83.1	63.0
	Gungaram	49.4	67.0	117.7	150.2	123.0	93.1	72.4	88.1	84.6	78.6	59.5	46.9
	Nagrifarm	37.2	43.7	99.1	106.6	68.1	68.6	72.5	79.2	68.9	74.9	70.1	50.5

? indicates data not available.